# Memorandum

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*Date:* *January 24, 2014*

*Subject:* *2012 Background Sediment Split Sample Data Comparison for the Lower Passaic River Study Area*

At the request of the United State Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (USACE), CDM Federal Programs Corporation (CDM Smith) collected oversight split background sediment samples as part of the Lower Passaic River (LPR) Restoration Project remedial investigation conducted by the Cooperating Parties Group (CPG). This memorandum presents the comparison of the EPA oversight team's split sample results to the CPG's sample results and discusses the differences in the datasets. In this document, samples will be referred to as either CPG samples or EPA samples for clarity.

The evaluation was conducted in two ways: (1) on an individual chemical basis and (2) on a chemical group basis. Normally, only the first of these (individual chemical basis) would be conducted, consistent with previous comparisons. However, due to the small number of data pairs available for the individual chemicals, which resulted in insufficient statistical power to discern differences, it was determined that the second method (chemical group basis) should also be conducted. The split sample data comparison for the 2012 Lower Passaic background sediment sampling oversight is based primarily on the second method except for total organic carbon (TOC) and mercury.

- Dioxins/Furans: For dioxins and furans as a group, there were statistically significant differences between the results of the EPA and CPG background sediment samples. Overall, the CPG results were higher than the EPA results.
- Pesticides: The analytical results for pesticides as a group were comparable for EPA and CPG split samples. Where differences existed, CPG sample results tended to be lower than EPA samples results.
- Polychlorinated Biphenyls (PCBs): The analytical results for PCBs as a group were comparable for EPA and CPG split samples. Where differences existed, CPG sample results tended to be higher than EPA samples results.

- Polycyclic Aromatic Hydrocarbons (PAHs): The analytical results for PAHs as a group were comparable for EPA and CPG split samples. Where differences existed, CPG sample results tended to be higher than EPA samples results.
- TOC: Though rigorous statistical testing was not possible due to the small sample size, the CPG results tended to be higher than the EPA results.
- Metals (excluding mercury): The analytical results for metals as a group were comparable for EPA and CPG split samples. Where differences existed, CPG sample results tended to be higher than EPA sample results.
- Mercury: The mercury results were comparable for CPG and EPA results.

## Oversight Program Summary

Oversight was conducted in accordance with the Final Quality Assurance Project Plan (QAPP), Addendum No. 12, Collection of Background Surface Sediment Samples. The split sample program consisted of four background sediment split samples collected from the study area, therefore results from four split sample pairs were compared for each of the analytical methods evaluated.

## Data Comparison Methodology

The CPG and EPA split sample data were evaluated for potential difference by plotting selected analytes (Table 1) for the following parameters. For each of the following three plots, data are plotted and evaluated only for the cases where both sample pairs are detected:

- Line Plot of Absolute Concentrations: The absolute concentrations measured by both analytical programs for the detected paired samples were plotted against the same axes. These graphs depict the relative magnitudes and patterns of concentrations.
- Bivariate Scatter Plot: CPG sample concentration was plotted as a function of EPA sample concentration for each detected pair. The bivariate plot illustrates the relationship between EPA and CPG data. Also included on each graph is a line which depicts a 1:1 ratio of EPA to CPG concentration. The bivariate plot can be used to identify potential systematic bias when data points fall consistently above or below the 1:1 line.
- Percent Difference Plot: The percent difference (%D) was defined as the difference between EPA and CPG concentration for detected data pairs, divided by the EPA sample concentration according to Equation 1.

$$\%\ D = \frac{(R_{USEPA} - R_{CPG})}{(R_{USEPA})}(100) \qquad \text{(Equation 1)}$$

Consequently, a negative %D indicates a CPG result that is higher than the EPA result, while a positive %D indicates a CPG result that is lower than the EPA result. This plot provides a visual

indication of the extent of positive and negative differences between the two datasets. The red dashed lines on the plot correspond to 40%D and -67%D. These criteria correspond to 50% relative percent difference (RPD) (the CPG's field duplicate acceptance criterion), converted to %D values. %D is commonly used when one of the two values is known or accepted, whereas RPD is more commonly used when both values are uncertain. The sample data in these graphs was represented with the EPA result as the known value and the CPG result as the unknown value.

In addition to the preparation of data comparison plots, the tests described below were also conducted for CPG and EPA data pairs where both results were detected.

- Average Ratio: The ratios of the CPG results to EPA results were calculated for each sample pair. The average ratio and standard deviation were calculated. An average ratio above one indicates that the CPG results were detected higher than the EPA results, while an average ratio below one indicates that the CPG results were detected lower than the EPA results.
- Percent Difference: The calculated %D values were evaluated against the acceptance criteria of greater than or equal to -67% or less than or equal to 40% (equivalent to less than or equal to 50% RPD). Since RPD is evaluated for results at least five times the sample reporting limit, only sample data pairs where both results were at least five times the sample reporting limit were included in the %D evaluation.
- Wilcoxon Signed Rank Test: The Wilcoxon Signed Rank test was used to calculate *p*-values for all detected sample pairs. The *p*-value is an indicator of the presence of a difference between the datasets. A *p*-value of less than 0.05 indicates a statistically significant difference between the two data sets. In addition to the regular Wilcoxon test for the detected data pairs, the Paired Prentice-Wilcoxon (PPW) test, a modified version of the Wilcoxon test, was utilized to allow inclusion of non-detected values. Further details on the PPW test are provided later in this memorandum.

The test criteria listed above were applied to two types of data groupings: (1) to the individual chemicals and (2) to the chemical groups as a whole. The data comparison plots associated with these two types of groupings are provided in Figures 1 through 48 for the individual chemicals, and in Figures 49 through 53 for the chemical groups. Results for the three statistical tests are presented in Table 1 for the individual chemicals and in Table 2 for the chemical groups. Other relevant information about the datasets is also provided in Tables 1 and 2. The numbers of split sample pairs are listed for each compound/group along with the number of pairs which had detected results for both samples. The average ratio of CPG sample results to EPA sample results are reported along with the standard deviation of the ratios. The %D results are summarized by reporting the percentage of data pairs that exceeded the acceptance criteria. Also included are the *p*-values calculated by the Wilcoxon Signed Rank test and PPW test.

An overall evaluation of the split sample data is based on the result of the three statistical tests, where each compound has a rating of "Same" or "Different". The datasets are considered comparable or "Same" if the criteria for at least two of the three statistical tests were met. When only the average ratio and Wilcoxon Signed Rank test (and/or PPW test) results were available, the overall ranking for each compound was considered comparable or "Same" if criteria for both tests were met. The criteria for each test are:

- Average Ratio: Average ratio of CPG to EPA within 0.70 to 1.30.
- Percent Difference: %D within 40 to -67% for the majority of the sample pairs, where no more than 16% of the data pairs exceed the acceptance criteria.
- Wilcoxon Signed Rank Test (and/or PPW test): *p*-values greater than or equal to 0.05 are within acceptance limits, indicating there is no significant difference between the data sets.

In summary, the split sample comparison of the 2012 LPR background sediment consisted of four sample pairs. The split comparison was therefore limited to four sample pairs analyzed for dioxins and furans, organochlorine pesticides, PCBs, PAHs, TOC, metals, and mercury.

As discussed previously, the results presented in Table 1 (individual chemical basis) are limited due to the small sample size of the data pairs for the individual organic compounds and metals available for the evaluation. Specifically, with only a maximum of four data pairs, the statistical power of the Wilcoxon Signed Rank test (and/or PPW test) is insufficient to discern a real difference for the paired data. While the nature of the actual reduction in statistical power resulting from testing with four or less four data pairs was not investigated, such reduction is inherent in any statistical-based comparison test and a good general rule-of-thumb is a minimum of 8 to10 samples or data pairs for robust statistical testing.

Due to the limitation for individual chemical data sets, a second evaluation (Table 2) was conducted whereby the data were tested as chemical groups: dioxins/furans, pesticides, PCBs, PAHs, and metals (excluding mercury). This testing was conducted to increase the number of sample pairs and thus increase statistical power. To account for differences in concentration ranges between the various compounds/metals within a group, each data pair was first scaled between 0 and 1 according to Equation 2,

$$y_i = \frac{R_i}{maximum(R_{USEPA,}R_{CPG})} \qquad \text{(Equation 2)}$$

where

| | | |
|---|---|---|
| $y_i$ | = | scaled data value for each individual data |
| $R_i$ | = | data value in the original concentration units |
| maximum ($R_{EPA}$, $R_{CPG}$) | = | the maximum concentration in the split sample pair |

The paired Wilcoxon test was then conducted on the scaled data pairs. It is noted that conducting the tests on chemical groups rather than on individual compounds/metals results in the loss of the ability to evaluate differences for the individual compounds/metals. In such a case where the test discerns a statistical difference for a chemical group, it is not possible to determine which individual compounds/metals within the group may be responsible for the difference.

The standard paired Wilcoxon test was conducted only on data pairs where both results were detected values. This protocol is consistent with previous split sample comparisons conducted at the LPR study area. However, it has been noted that the elimination of data pairs containing nondetected values is essentially equivalent to ignoring potentially substantial information contained within these nondetect-containing data pairs, and may lead to biased results, and that therefore an attempt should be made to include them in the analyses. Therefore, in addition to the standard paired Wilcoxon test conducted on the detected data pairs only, a modified version of the test called the PPW test was conducted that allows inclusion of the left-censored (non-detected) data pairs. The PPW test relies on survival analysis computations as detailed in O'Brien and Fleming (1987) and is considered the standard test for the case of censored matched pairs (Helsel 2005).

Below are some notable observations from Tables 1 and 2 and Figures 1 through 53. As mentioned earlier, the statistical power of the Wilcoxon Signed Rank test and/or the PPW test is insufficient to discern a real difference for the paired data for individual compounds due to the small sample size (<5). Thus, only results for the average ratio and %D are discussed below for individual compounds.

## Dioxins/Furans

There was a high degree of variance between the CPG and EPA results for dioxin congener analysis. Of the six dioxin/furan congeners and total tetrachlorodibenzo-p-dioxin (TCDD) evaluated, only 2,3,7,8-TCDD and 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF)met the criteria for average ratios and %D, indicating that the split samples were comparable for these two congeners. For all other dioxin/furan congeners and total TCDD, the average ratio and %D exceeded acceptance criteria (Table 1). Differences are observed between the two data sets for 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF, OCDD, OCDF, and total TCDD based on the average ratio and %D. The CPG results were distinctly higher than the EPA results.

The differences between the dioxin data sets were further confirmed by the group testing. There was a statistically significant difference between the EPA and CPG samples. The average ratio and %D also exceeded acceptance criteria (Table 2). As shown in Figures 1 through 7 and Figure 49, overall the CPG results were high in comparison to the EPA results.

## Pesticides

The comparison of analytical results between the EPA and the CPG showed comparable results for the majority of the pesticides. The average ratios criterion was met for all pesticides except 2,4'-dichlorodiphenyldichloroethane (DDD). The %D criterion was met for all pesticides except 2,4'-DDD and 4,4'-DDD. All pesticides data were comparable except 2,4'-DDD, where the CPG results were lower than the EPA results. From examination of individual sample pairs, the most marked discrepancy was observed for the 2,4'-DDD results for sample UPRT18C, where the CPG result was nearly 50 times lower than the EPA result.

The analytical results for pesticides as a group were comparable for EPA and CPG split samples. The PPW test did indicate that the data sets were different, but all other data evaluation indicated that the data sets were comparable.

## Polychlorinated Biphenyls

The comparison of analytical results between the EPA and the CPG showed comparable results for the majority of the individual PCB congeners. Eight of the 11 PCB congeners evaluated and total PCB results were within the acceptable average ratios criterion. However, seven congeners and total PCB had %D exceeding the acceptance criterion. Differences were found between the data sets for 3,3',4,4'-tetrachlorobiphenyl (PCB 77), 3,4,4',5-tetrachlorobiphenyl (PCB 81), and 2,3,4,4',5-pentachlorobiphenyl (PCB 114) based on the average ratio and %D. The CPG results were higher than the EPA results for these congeners.

For PCBs as a group, the analytical data between the EPA and CPG samples were comparable, although the %D exceeded the acceptance criterion.

## Polycyclic Aromatic Hydrocarbons

The split sample data were comparable for all individual PAH compounds except fluoranthene. All of the PAHs had average ratios within criterion except fluoranthene. Five of nine PAHs had %D within the criterion. The CPG results for fluoranthene were higher than the EPA results.

All three criteria indicated that there was no statistically significant difference between the EPA and CPG samples for PAHs as a group.

## Total Organic Carbon

Differences were found between the two data sets for the TOC results, based on the average ratio and %D. The CPG results were higher than the EPA results (Table 1 and Figure 37). However, due to small sample size, the Wilcoxon Signed Rank test and the PPW test are insufficient to discern a real difference for the paired data.

### Metals (excluding mercury)

The comparison of analytical results between the EPA and the CPG showed comparable results for the majority of metals. The average ratios were within the criterion for all metals except cadmium and lead. Six of ten metals had %D exceeding the criterion. Overall, the metal data are comparable except cadmium and lead. The CPG results were higher than the EPA results for these two metals. A notable discrepancy was noted for cadmium in sample UPRT20A. The CPG cadmium result was nearly 30 times higher than EPA result.

For metals as a group, there was no statistically significant difference between the EPA samples and CPG samples, though the %D exceeded the criterion.

### Mercury

The mercury results were comparable for CPG and EPA results, based on the average ratio and %D.

## Recommendations

Due to the small sample size (<5), the statistical power of the Wilcoxon signed rank test is greatly limited to identify a difference between the CPG and EPA data sets. In order to obtain meaningful statistical results for individual chemicals, at least 8 to 10 (preferably 15 to 20) split samples are recommended to collect during each oversight task, even if the number of split samples exceeds 10% of the number of the total samples.

Ignoring nondetects in the statistical comparison testing is an unnecessary practice, and hence should be avoided in future split sample comparisons. In this particular case, the PPW test should be conducted in lieu of the standard Wilcoxon test on detected values only.

## Attachments

Table 1: Lower Passaic River 2012 Background Sediment Sampling Comparison Summary by Individual Compounds

Table 2: Lower Passaic River 2012 Background Sediment Sampling Comparison Summary by Chemical Categories

Figures 1 through 53: Statistical Linear Plots

a. Line Plots of Absolute/Scaled Concentrations
b. Bivariate Scatter Plots
c. Percent Differences Plots

| | |
|---|---|
| Figures 1 through 7: | Plots of Dioxin/Furan Concentrations |
| Figures 8 through 15: | Plots of Pesticide Concentrations |
| Figures 16 through 27: | Plots of Polychlorinated Biphenyl (PCB) Concentrations |
| Figures 28 through 36: | Plots of Polycyclic Aromatic Hydrocarbon (PAH) Concentrations |
| Figure 37: | Plots of Total Organic Carbon (TOC) Concentrations |
| Figures 38 through 47: | Plots of Metal Concentrations |
| Figure 48: | Plots of Mercury Concentrations |
| Figure 49: | Plots of Dioxins/Furans Scaled Concentrations |
| Figure 50: | Plots of Pesticides Scaled Concentrations |
| Figure 51: | Plots of PCBs Scaled Concentrations |
| Figure 52: | Plots of PAHs Scaled Concentrations |
| Figure 53: | Plots of Metals (excluding mercury) Scaled Concentrations |

## References

Helsel, D.L. 2005. Nondetects and Data Analysis, Statistics for Censored Environmental Data, Wiley-Interscience. 250p.

O'Brien, P.C. and T.R. Fleming. 1987. A paired Prentice-Wilcoxon test for censored paired data, Biometrics. 43, 169-180.

Table 1
Lower Passaic River 2012 Background Sediment Sampling Comparison Summary by Individual Compounds

| Parameter | Number of Split Sample Pairs | Number of Split Sample Paris with Detected Concentrations | Average Ratio of CPG to EPA (for detected pairs)(1) | Percent Difference (for detected pairs) [2] | *p* -value | | | Overall Split Sample Comparison (Same or Different) [6] |
|---|---|---|---|---|---|---|---|---|
| | | | | | Wilcoxon Signed Rank test [3] | Paired Prentice Wilcoxon test [4] | Statistical Difference (Yes or No) [5] | |
| **Dioxins/Furans** | | | | | | | | |
| 1,2,3,4,6,7,8-HpCDD | 4 | 3 | **1.57±0.77** | **33% Outside Criteria** | 0.789 | 0.564 | No | Different |
| 1,2,3,4,6,7,8-HpCDF | 4 | 3 | **1.85±0.70** | **67% Outside Criteria** | 0.181 | 0.083 | No | Different |
| 2,3,7,8-TCDD | 4 | 3 | 0.91±0.29 | Within Range | 0.423 | 0.206 | No | Same |
| 2,3,7,8-TCDF | 4 | 3 | 1.16±0.27 | Within Range | 1.000 | 0.564 | No | Same |
| OCDD | 4 | 3 | **1.90±0.70** | **67% Outside Criteria** | 0.181 | 0.132 | No | Different |
| OCDF | 4 | 3 | **2.38±1.17** | **67% Outside Criteria** | 0.181 | 0.083 | No | Different |
| Total TCDD | 4 | 4 | **1.90±0.83** | **25% Outside Criteria** | 0.100 | 0.058 | No | Different |
| **Pesticides** | | | | | | | | |
| 4,4'-DDD | 4 | 3 | 0.90±0.36 | **33% Outside Criteria** | 0.423 | 0.564 | No | Same |
| 4,4'-DDE | 4 | 4 | 0.89±0.14 | Within Range | 0.201 | 0.527 | No | Same |
| 4,4'-DDT | 4 | 3 | 1.05±0.38 | Within Range | 0.789 | 0.459 | No | Same |
| Dieldrin | 4 | 3 | 0.85±0.04 | Within Range | 0.181 | 0.046 | No | Same |
| alpha-Chlordane | 4 | 3 | 1.02±0.22 | Within Range | 0.789 | 1.000 | No | Same |
| 2,4'-DDD | 4 | 3 | **0.59±0.61** | **67% Outside Criteria** | 0.423 | 0.299 | No | Different |
| 2,4'-DDE | 4 | 2 | 0.84±0.05 | Within Range | 0.371 | 0.157 | No | Same |
| 2,4'-DDT | 4 | 1 | NA | Within Range | NA | 0.194 | No | Same |
| **Polychlorinated Biphenyls (PCBs)** | | | | | | | | |
| 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) | 4 | 3 | **1.48±0.60** | **33% Outside Criteria** | 0.181 | 0.083 | No | Different |
| 3,4,4',5-Tetrachlorobiphenyl (PCB 81) | 4 | 2 | **1.69±1.30** | **50% Outside Criteria** | 1.000 | 0.527 | No | Different |
| 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) | 4 | 3 | 1.22±0.52 | **33% Outside Criteria** | 0.789 | 0.739 | No | Same |
| 2,3,4,4',5-Pentachlorobiphenyl (PCB 114) | 4 | 3 | **1.33±0.59** | **33% Outside Criteria** | 0.789 | 0.467 | No | Different |
| 2,3',4,4',5-Pentachlorobiphenyl (PCB 118) | 4 | 4 | 1.22±0.40 | **25% Outside Criteria** | 0.584 | 1.000 | No | Same |
| 2',3,4,4',5-Pentachlorobiphenyl (PCB 123) | 4 | 2 | 1.14±0.24 | Within Range | 1.000 | 1.000 | No | Same |
| 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) | 4 | 2 | 1.09±0.48 | Within Range | 1.000 | 1.000 | No | Same |
| 2,3,3',4,4',5-Hexachlorobiphenyl+2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156+157) | 4 | 3 | 1.10±0.30 | Within Range | 1.000 | 0.564 | No | Same |
| 2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167) | 4 | 3 | 0.95±0.11 | Within Range | 0.789 | 0.564 | No | Same |
| 3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169) | 4 | 0 | NA | NA | NA | 0.317 | No | NA |
| 2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189) | 4 | 2 | 0.71±0.21 | **50% Outside Criteria** | 0.371 | 0.196 | No | Same |
| Total PCB | 4 | 4 | 0.85±0.53 | **25% Outside Criteria** | 0.584 | 0.450 | No | Same |
| **Polycyclic Aromatic Hydrocarbons (PAHs)** | | | | | | | | |
| Anthracene | 4 | 3 | 1.02±0.37 | Within Range | 0.789 | 0.564 | No | Same |
| Benzo[a]anthracene | 4 | 3 | 1.11±0.29 | Within Range | 1.000 | 0.564 | No | Same |
| Benzo[a]pyrene | 4 | 3 | 0.97±0.30 | Within Range | 0.789 | 0.564 | No | Same |
| Chrysene | 4 | 3 | 0.89±0.26 | Within Range | 0.789 | 0.564 | No | Same |
| Fluoranthene | 4 | 3 | **1.33±0.50** | **33% Outside Criteria** | 1.000 | 0.564 | No | Different |
| Indeno[1,2,3-cd]pyrene | 4 | 3 | 1.04±0.34 | Within Range | 0.789 | 0.564 | No | Same |
| Naphthalene | 4 | 3 | 0.88±0.45 | **33% Outside Criteria** | 0.423 | 0.879 | No | Same |
| Phenanthrene | 4 | 3 | 1.30±0.63 | **33% Outside Criteria** | 1.000 | 0.564 | No | Same |
| Pyrene | 4 | 3 | 1.25±0.41 | **33% Outside Criteria** | 1.000 | 0.564 | No | Same |
| **Total Organic Carbon (TOC)** | | | | | | | | |
| TOC | 4 | 3 | **2.03±1.33** | **33% Outside Criteria** | 0.423 | 0.366 | No | Different |
| **Metals** | | | | | | | | |
| Arsenic | 4 | 4 | 0.77±0.21 | **25% Outside Criteria** | 0.201 | 0.225 | No | Same |
| Barium | 4 | 4 | 1.12±0.72 | **50% Outside Criteria** | 0.855 | 0.564 | No | Same |
| Cadmium | 4 | 4 | **8.7±13.08** | **50% Outside Criteria** | 0.100 | 0.088 | No | Different |
| Chromium | 4 | 4 | 1.14±0.37 | Within Range | 0.584 | 1.000 | No | Same |
| Cobalt | 4 | 4 | 1.03±0.38 | **25% Outside Criteria** | 1.000 | 0.739 | No | Same |
| Copper | 4 | 4 | 1.01±0.46 | **25% Outside Criteria** | 0.855 | 1.000 | No | Same |
| Iron | 4 | 4 | 0.85±0.42 | **25% Outside Criteria** | 0.584 | 0.217 | No | Same |
| Lead | 4 | 4 | **1.37±0.25** | **25% Outside Criteria** | 0.100 | 0.058 | No | Different |
| Nickel | 4 | 4 | 1.01±0.33 | Within Range | 0.855 | 0.670 | No | Same |
| Zinc | 4 | 4 | 1.18±0.27 | Within Range | 0.201 | 0.317 | No | Same |
| Mercury | 4 | 3 | 0.90±0.21 | Within Range | 1.000 | 0.564 | No | Same |

Results outside acceptance criteria are bolded.

NA = not applicable

EPA = United States Environmental Protection Agency

CPG = Cooperating Parties Group

Notes:

(1) Average ratio (criteria: 0.70-1.30) with standard deviation

(2) Percent difference criteria: no more than 16% of split samples outside of 40 to -67 %D.

(3) Wilcoxon Signed Rank test was employed at significance level (p) of 0.05

(4) Paired Prentice Wilcoxon test was employed at significance level (p) of 0.05

(5) Limited statistical power due to small sample size (less than five)

(6) If there are at least two of the three criteria (average ratio, percent different and statistical difference) met, the overall split sample comparison would be labeled "same". Otherwise, it would be "different".

Abbreviations:

1,2,3,4,6,7,8-HpCDD = 1,2,3,4,6,7,8- heptachlorodibenzo-p-dioxin
1,2,3,4,6,7,8-HpCDF = 1,2,3,4,6,7,8- heptachlorodibenzofuran
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
2,3,7,8-TCDF = 2,3,7,8-tetrachlorodibenzofuran
OCDD = octachlorodibenzo-p-dioxin
OCDF = octachlorodibenzofuran
Total TCDD = total tetrachlorodibenzo-p-dioxin
Total PCB = total polychlorinated biphenyl
2,4'-DDD = 2,4'-dichlorodiphenyldichloroethane
2,4'-DDE = 2,4'-dichlorodiphenyldichloroethylene
2,4'-DDT = 2,4'-dichlorodiphenyltrichloroethane
4,4'-DDD = 4,4'-dichlorodiphenyldichloroethane
4,4'-DDE = 4,4'-dichlorodiphenyldichloroethylene
4,4'-DDT = 4,4'-dichlorodiphenyltrichloroethane

Table 2
Lower Passaic River 2012 Background Sediment Sampling Comparison Summary by Chemical Categories

| Parameter | Number of Split Sample Pairs | Number of Split Sample Paris with Detected Concentrations | Average Ratio of CPG to EPA (for detected pairs)(1) | Percent Difference (for detected pairs) [2] | *p* -value | | | Overall Split Sample Comparison (Same or Different) [5] |
|---|---|---|---|---|---|---|---|---|
| | | | | | Wilcoxon Signed Rank test [3] | Paired Prentice Wilcoxon test [4] | Statistical Difference (Yes or No) | |
| Dioxins/Furans | 24 | 18 | **1.63±0.79** | **39% Outside Criteria** | **0.009** | **0.027** | Yes | Different (CPG higher than EPA) |
| Pesticides | 32 | 22 | 0.87±0.30 | 14% Outside Criteria | **0.041** | **0.015** | Yes | Same |
| Polychlorinated Biphenyls (PCBs) | 48 | 31 | 1.20±0.49 | **19% Outside Criteria** | 0.207 | 0.652 | No | Same |
| Polycyclic Aromatic Hydrocarbons (PAHs) | 36 | 27 | 1.09±0.38 | 15% Outside Criteria | 0.710 | 0.904 | No | Same |
| Metals (excluding mercury) | 40 | 40 | 1.82±4.32 [6] | **23% Outside Criteria** | 0.317 | 0.311 | No | Same |

Results outside acceptance criteria are bolded.

NA = not applicable EPA = United States Environmental Protection Agency CPG = Cooperating Parties Group

Notes:
(1) Average ratio (criteria: 0.70-1.30) with standard deviation
(2) Percent difference criteria: no more than 16% of split samples outside of 40 to -67 %D.
(3) Wilcoxon Signed Rank test was employed at significance level (p) of 0.05
(4) Paired Prentice Wilcoxon test was employed at significance level (p) of 0.05
(5) If there are at least two of the three criteria (average ratio, percent different and statistical difference) met, the overall split sample comparison would be labeled "same". Otherwise, it would be "different".
(6) Although average ratio (1.82) is not within criterion, the actual average ratio can be within criterion because of the high standard deviation (4.32).

**Figure 1a: Line Plot of 1,2,3,4,6,7,8-HpCDD Concentrations**

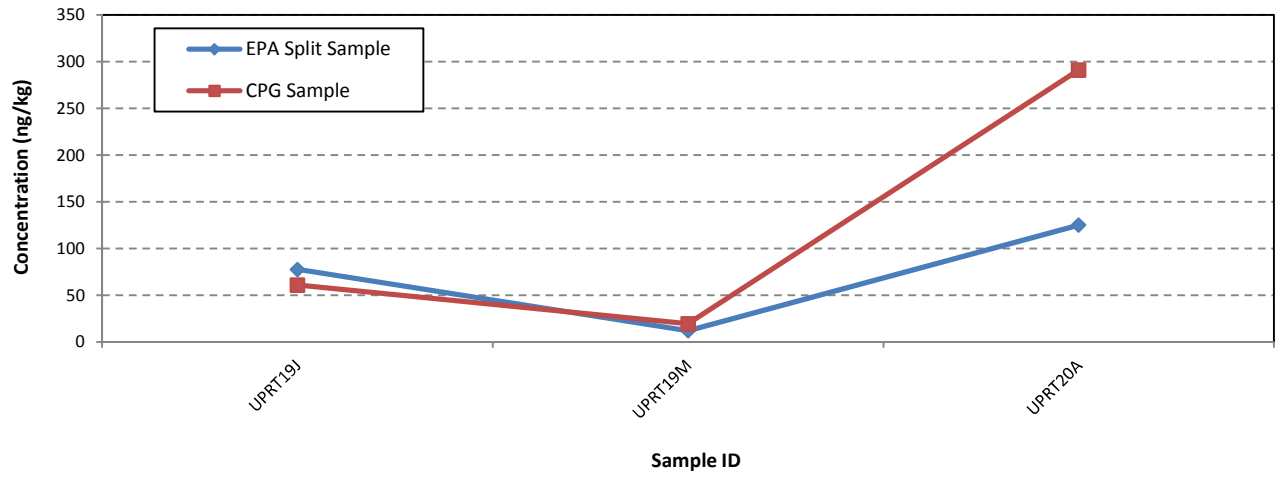



**Figure 1b: Bivariate Plot of 1,2,3,4,6,7,8-HpCDD Concentrations**

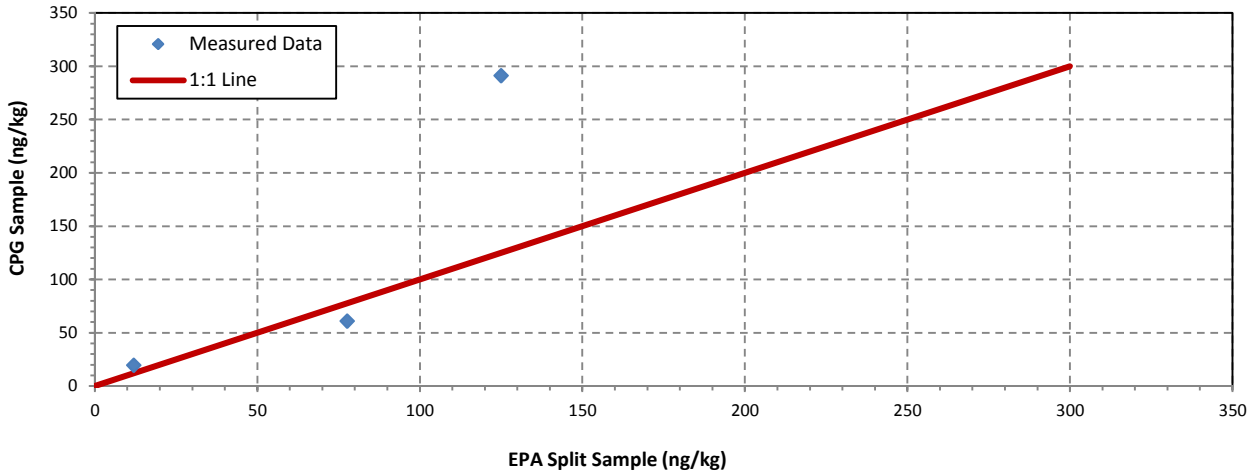
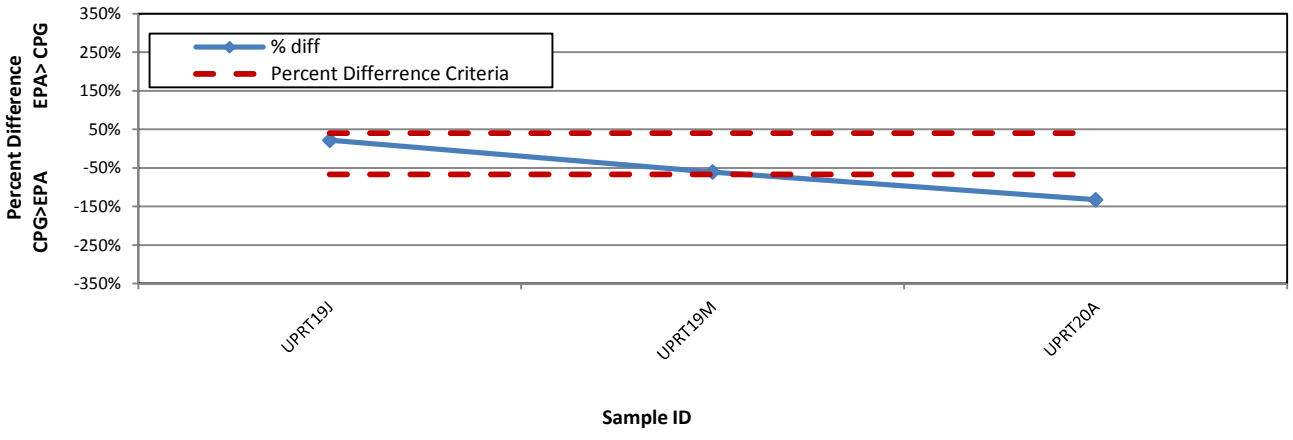



**Figure 1c: Line Plot of 1,2,3,4,6,7,8-HpCDD Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment 1,2,3,4,6,7,8-HpCDD Concentrations**

**Figure 1**

1,2,3,4,6,7,8-HpCDD = 1,2,3,4,6,7,8- heptachlorodibenzo-p-dioxin

CDM Smith

**Figure 2a: Line Plot of 1,2,3,4,6,7,8-HpCDF Concentrations**

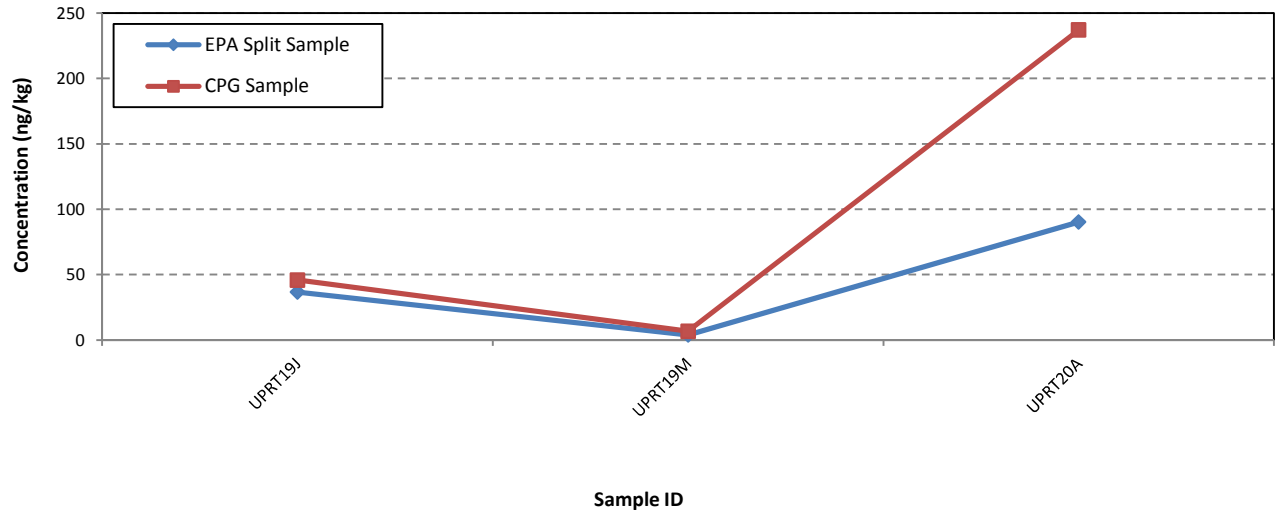



**Figure 2b: Bivariate Plot of 1,2,3,4,6,7,8-HpCDF Concentrations**

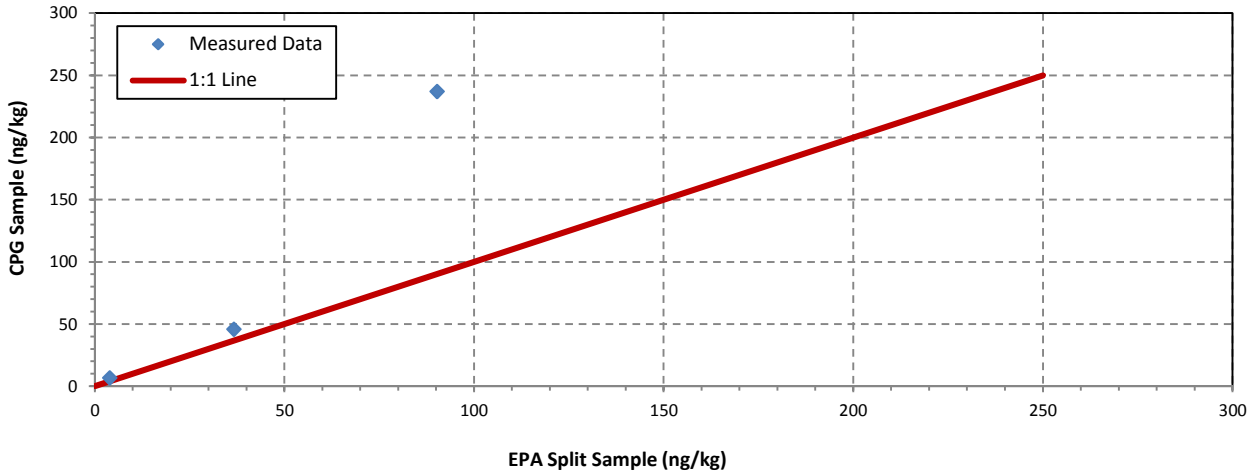
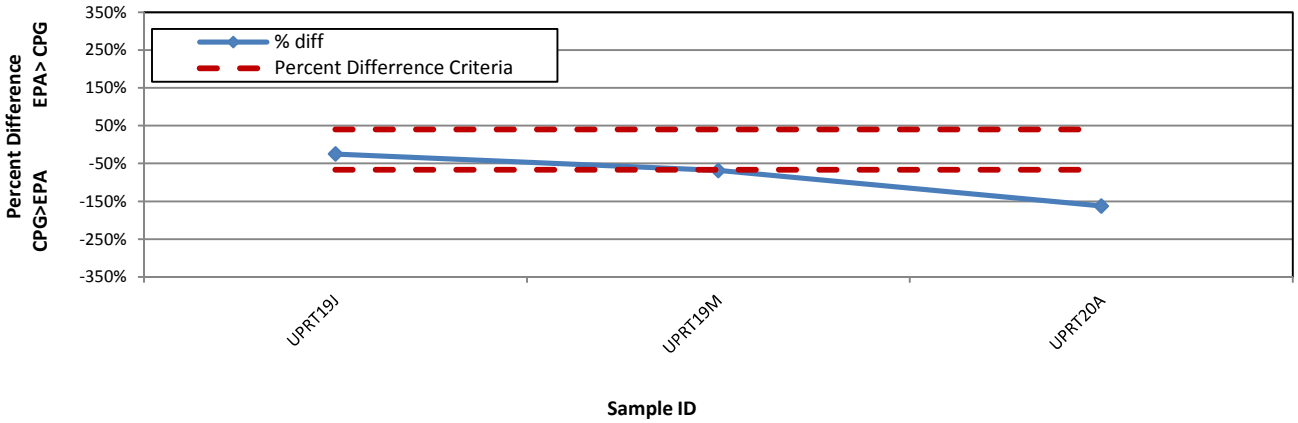



**Figure 2c: Line Plot of 1,2,3,4,6,7,8-HpCDF Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 1,2,3,4,6,7,8-HpCDF Concentrations**

**Figure 2**

1,2,3,4,6,7,8-HpCDF = 1,2,3,4,6,7,8- heptachlorodibenzofuran

CDM Smith

**Figure 3a: Line Plot of 2,3,7,8-TCDD Concentrations**

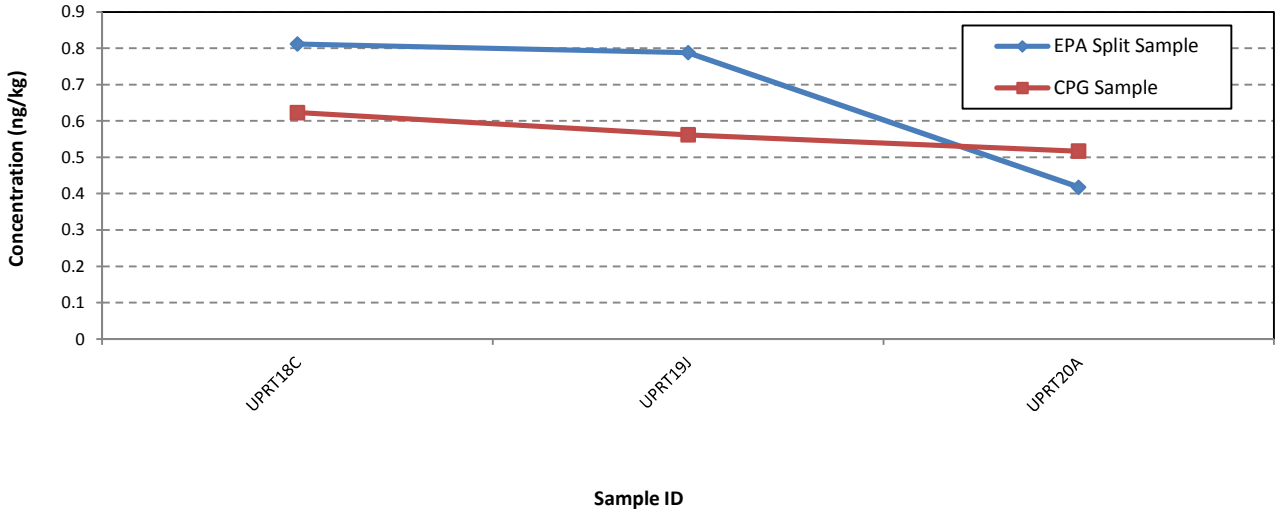



**Figure 3b: Bivariate Plot of 2,3,7,8-TCDD Concentrations**

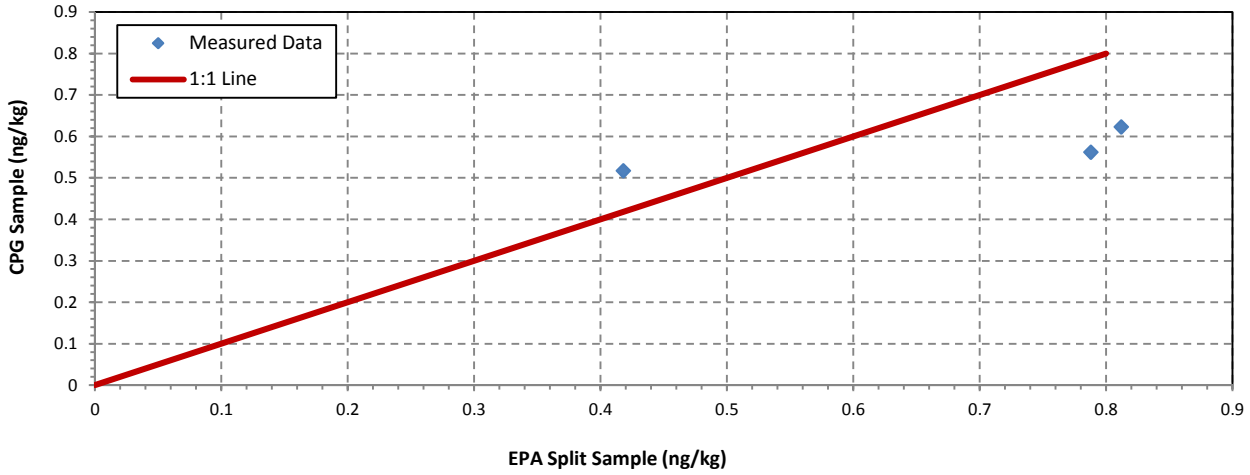
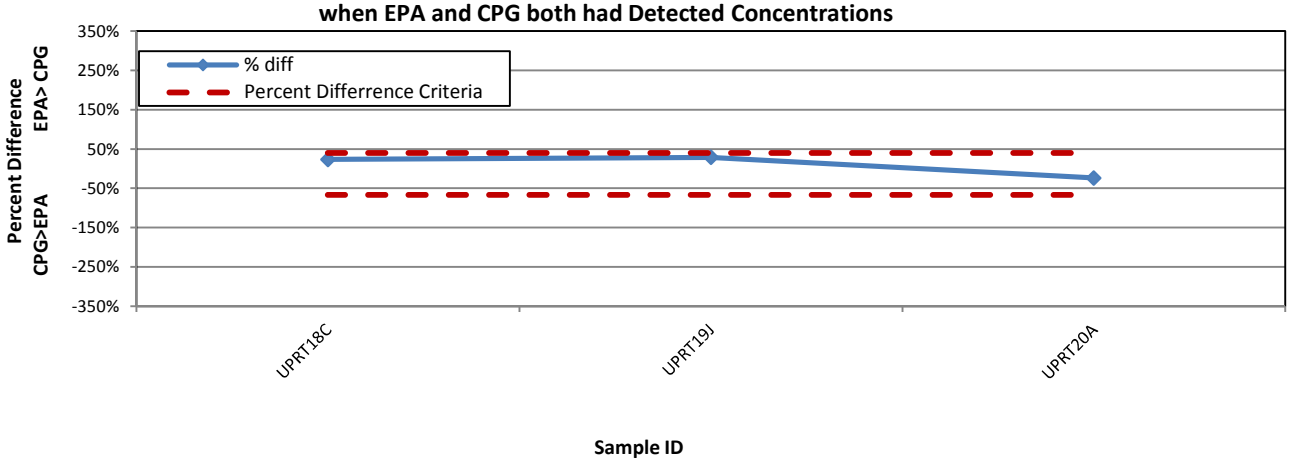



**Figure 3c: Line Plot of 2,3,7,8-TCDD Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment 2,3,7,8-TCDD Concentrations** | **Figure 3**

2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin

CDM Smith

**Figure 4a: Line Plot of 2,3,7,8-TCDF Concentrations**

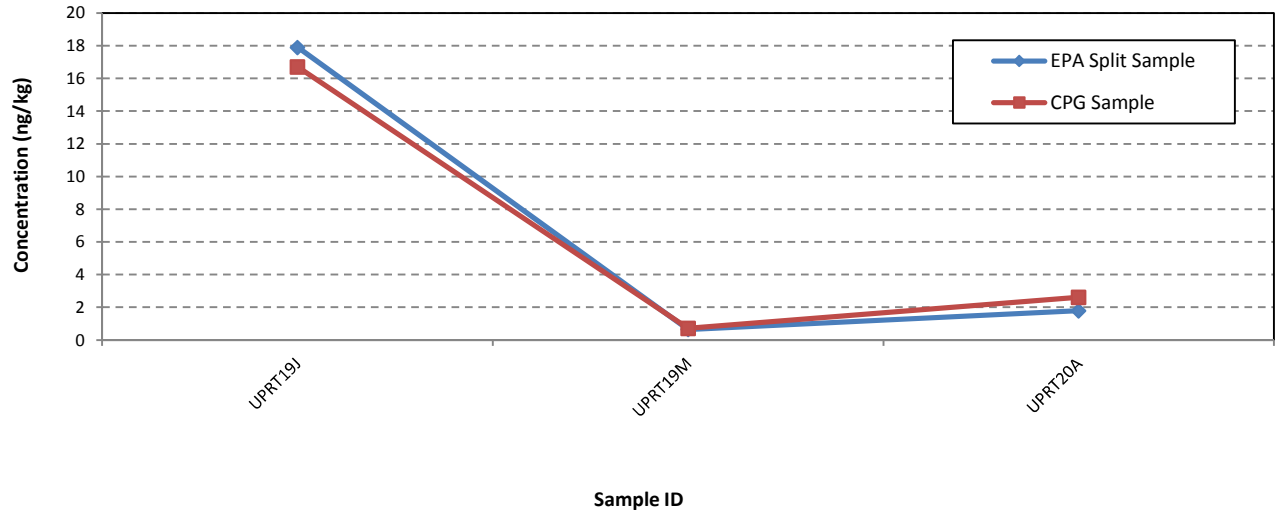



**Figure 4b: Bivariate Plot of 2,3,7,8-TCDF Concentrations**

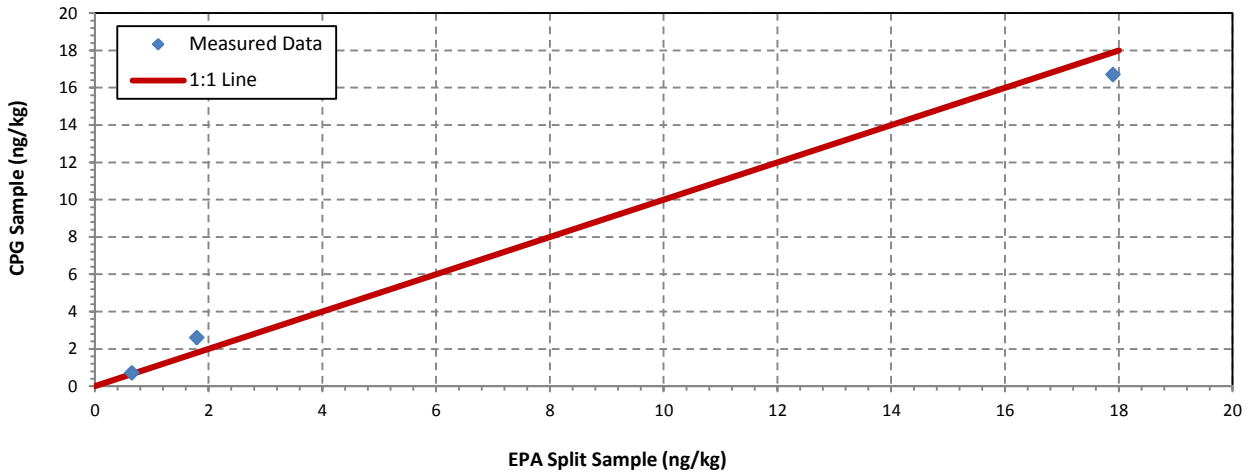
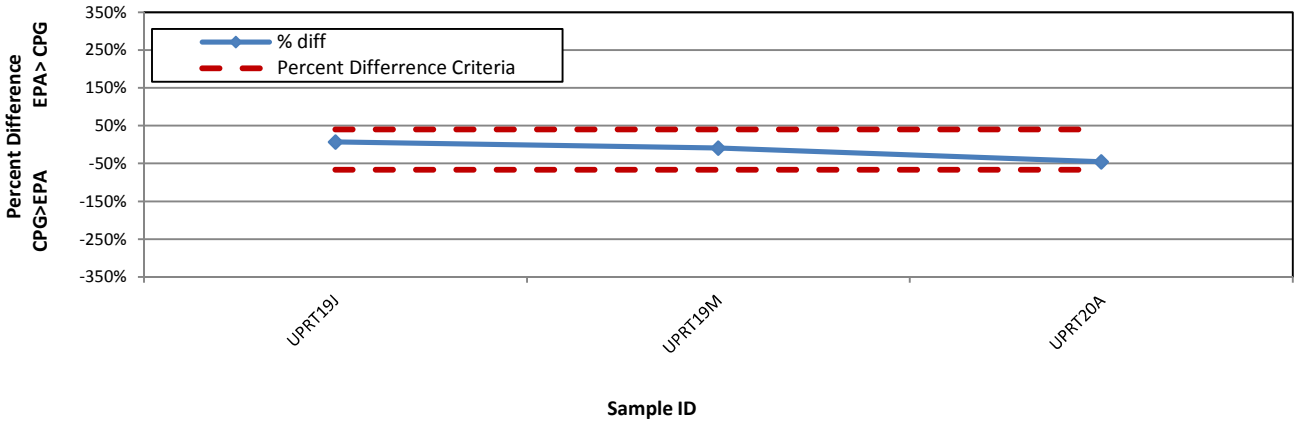



**Figure 4c: Line Plot of 2,3,7,8-TCDF Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers® | **Statistical Plot of Sediment 2,3,7,8-TCDF Concentrations** | **Figure 4** |

2,3,7,8-TCDF = 2,3,7,8-tetrachlorodibenzofuran

CDM Smith

**Figure 5a: Line Plot of OCDD Concentrations**

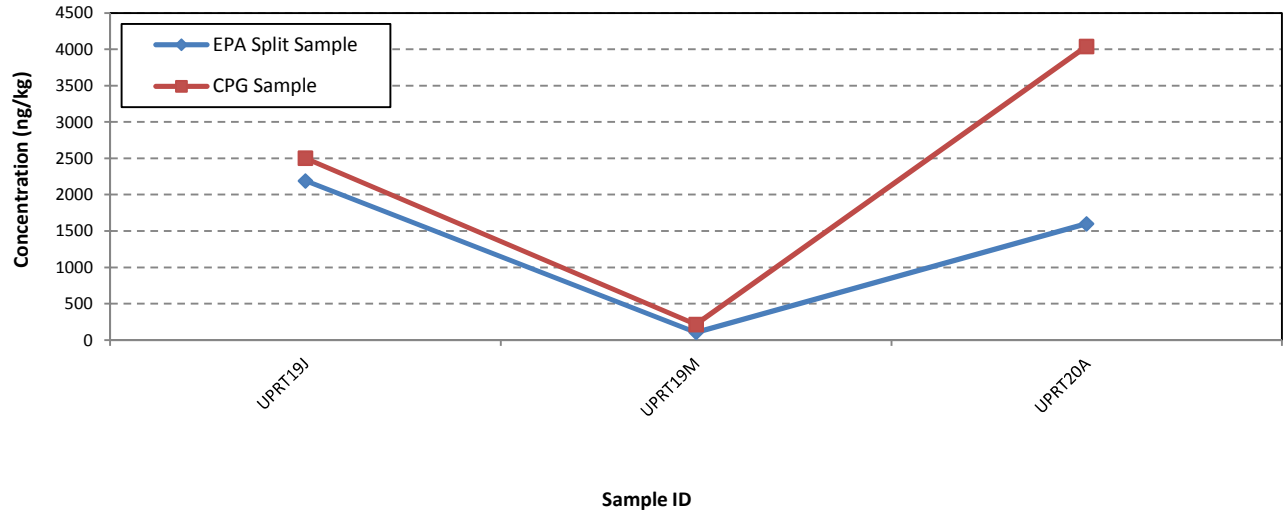



**Figure 5b: Bivariate Plot of OCDD Concentrations**

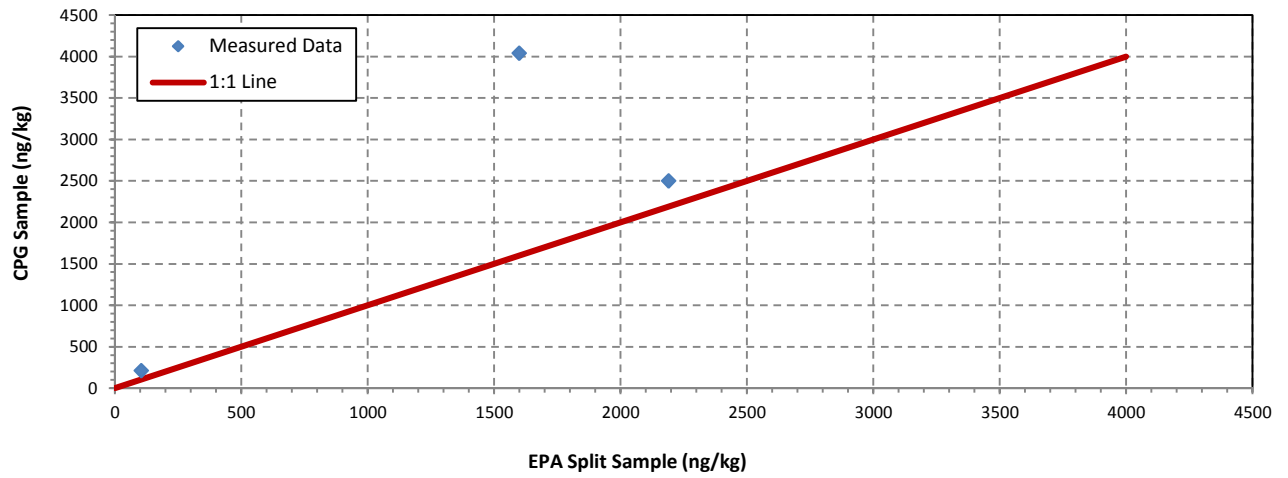
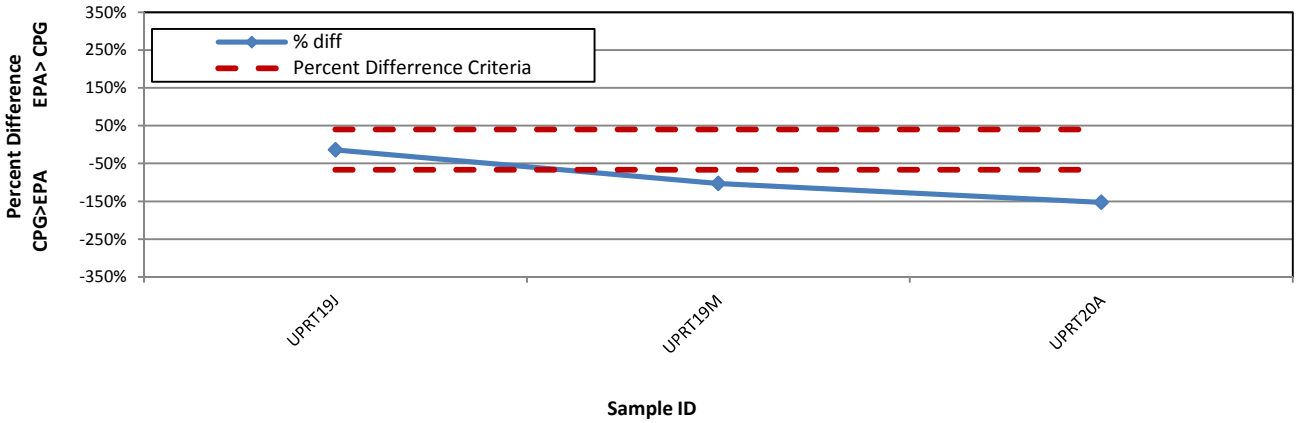



**Figure 5c: Line Plot of OCDD Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment OCDD Concentrations** | **Figure 5**

OCDD = octachlorodibenzo-p-dioxin

CDM Smith

**Figure 6a: Line Plot of OCDF Concentrations**

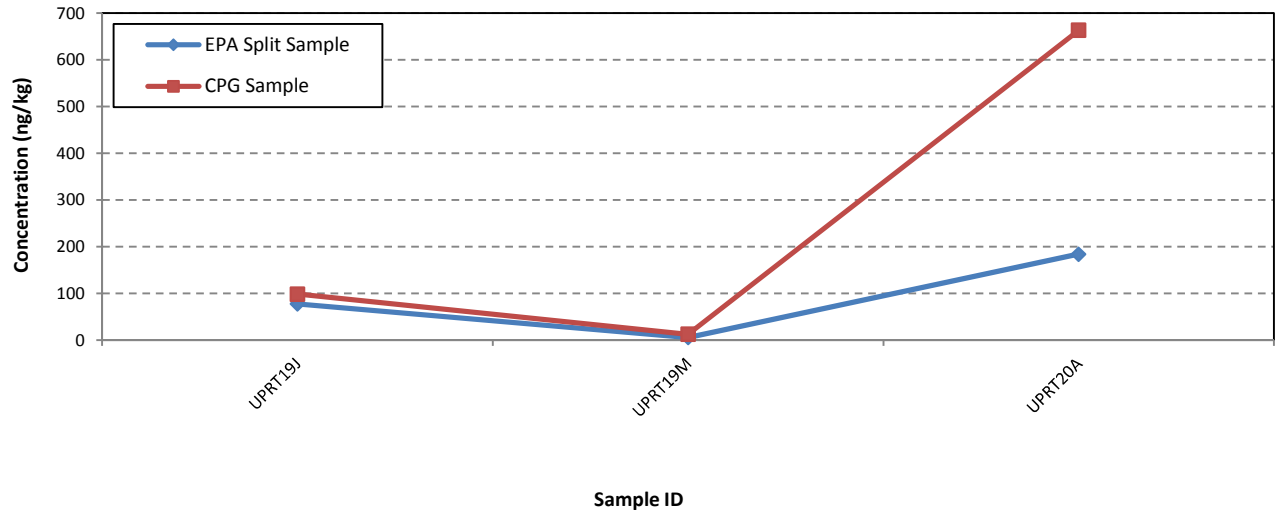



**Figure 6b: Bivariate Plot of OCDF Concentrations**

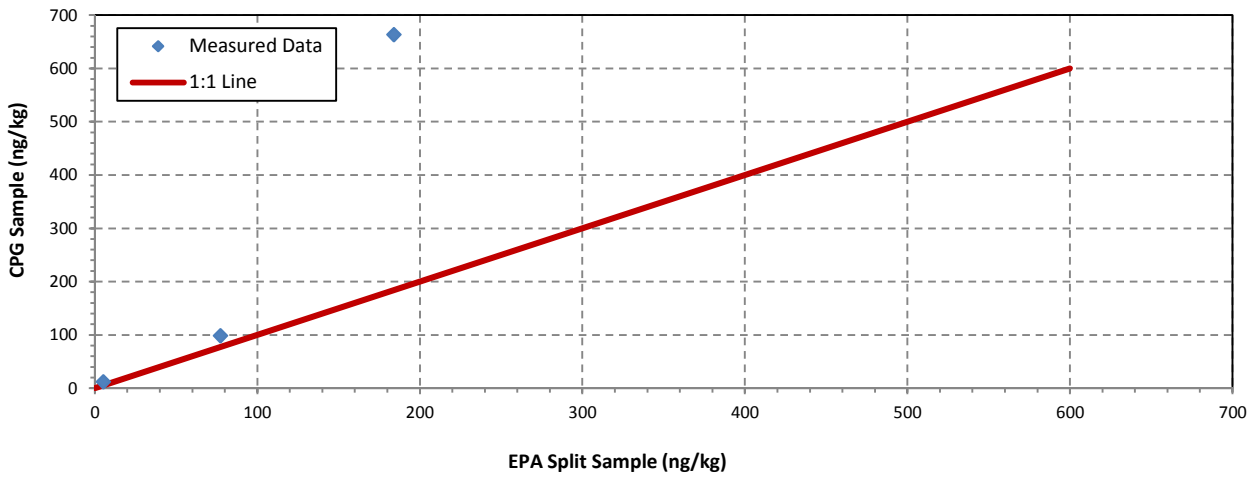
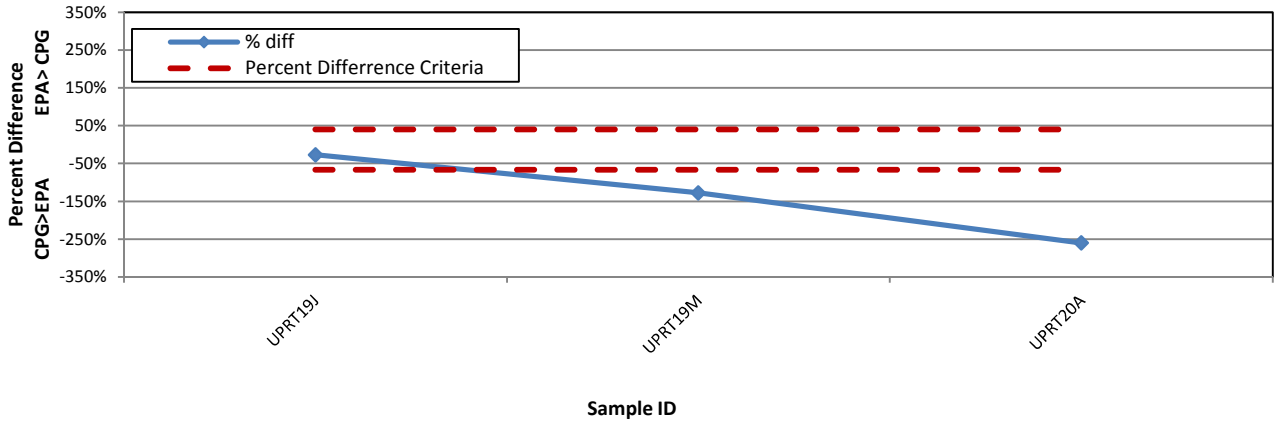



**Figure 6c: Line Plot of OCDF Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment OCDF Concentrations**

**Figure 6**

OCDF = octachlorodibenzofuran

CDM Smith

**Figure 7a: Line Plot of Total TCDD Concentrations**

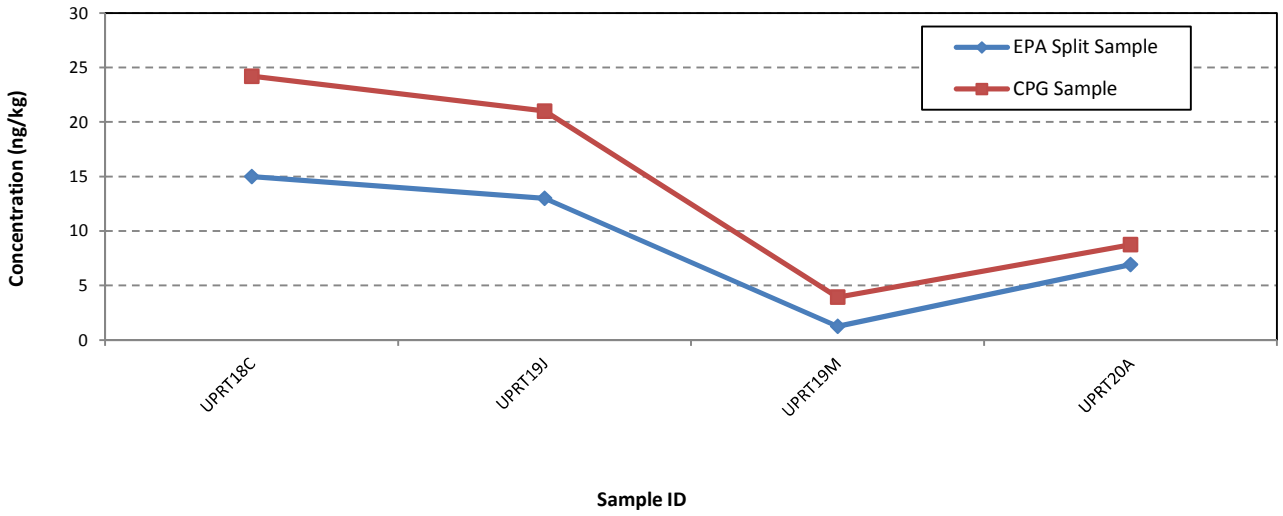



**Figure 7b: Bivariate Plot of Total TCDD Concentrations**

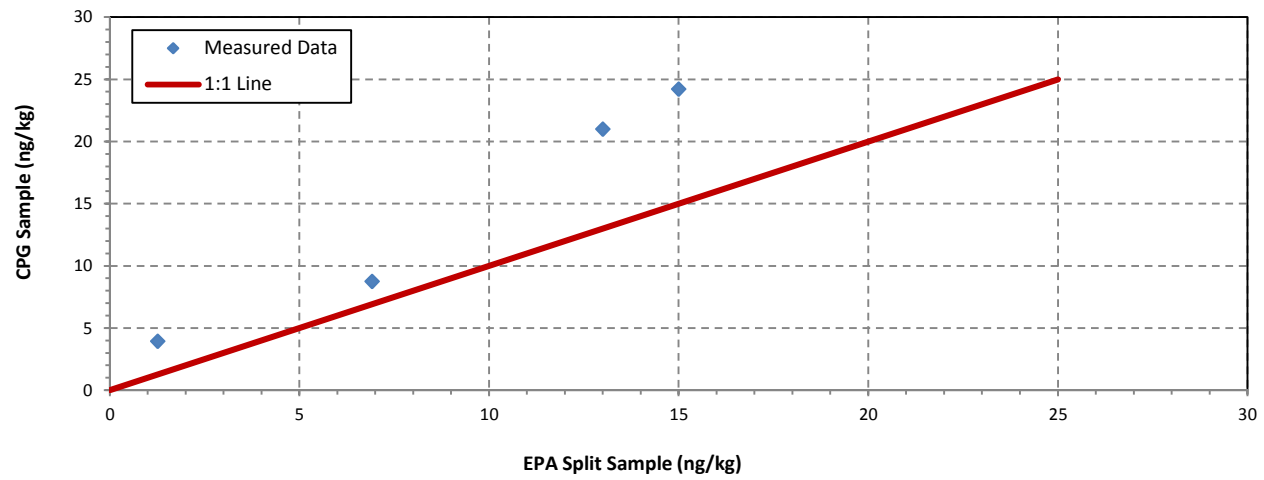
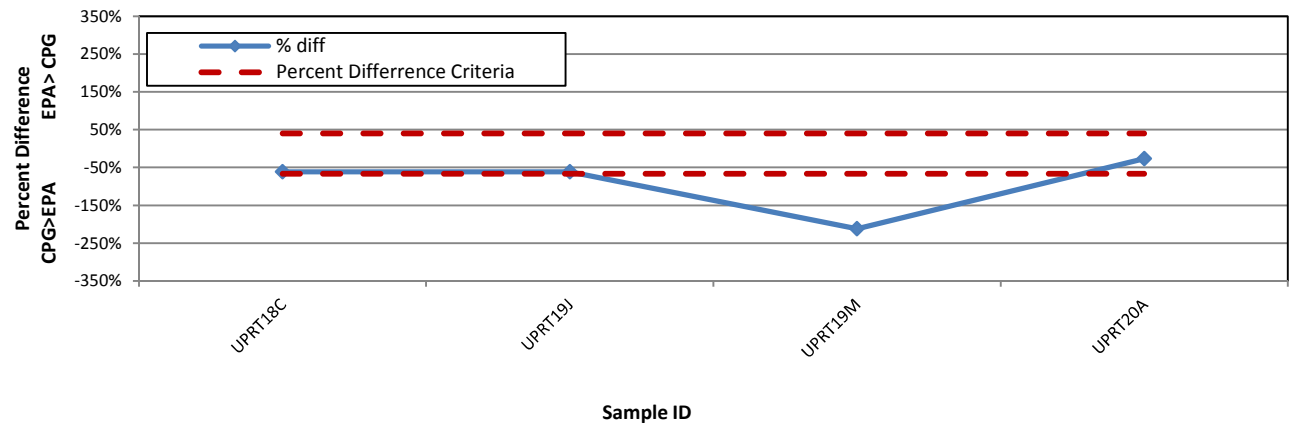



**Figure 7c: Line Plot of Total TCDD Percent Differences when EPA and CPG both had Detected Concentrations**

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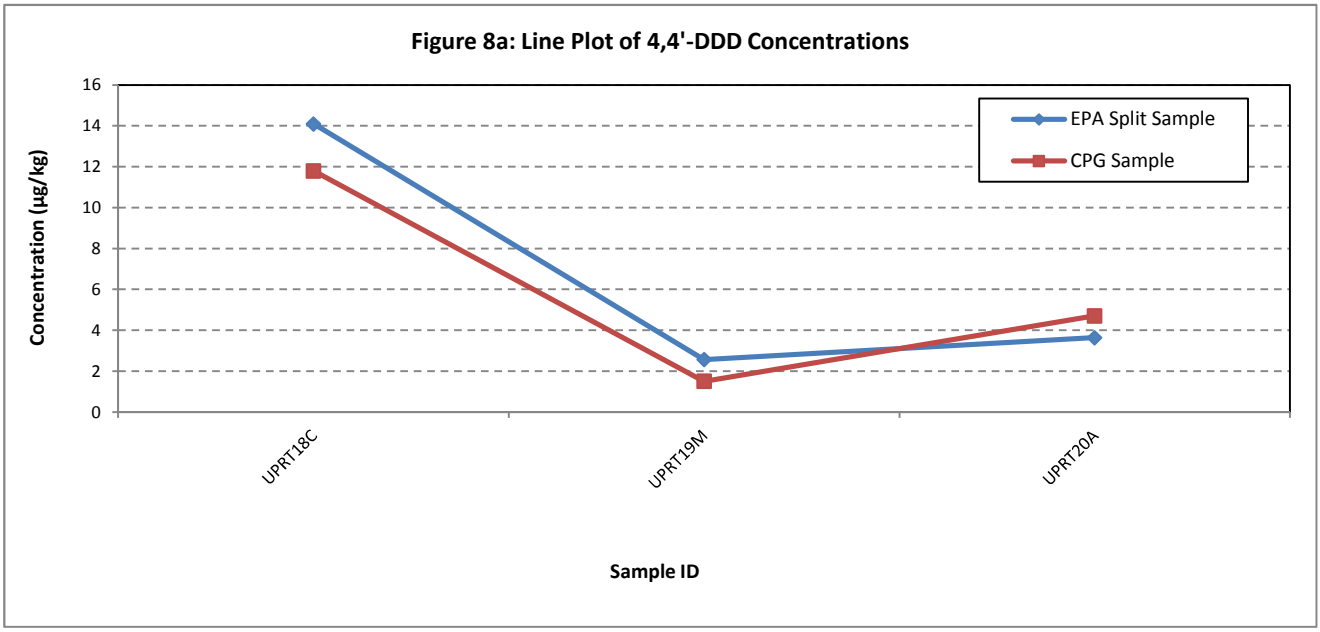
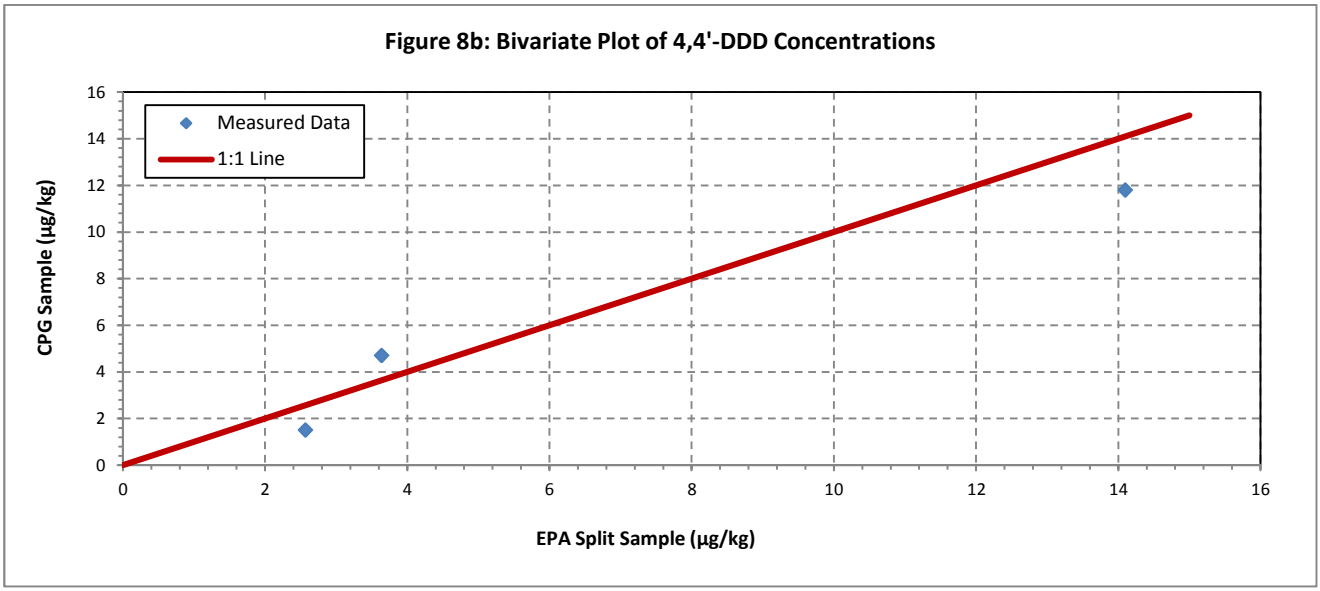
**Statistical Plot of Sediment Total TCDD Concentrations**

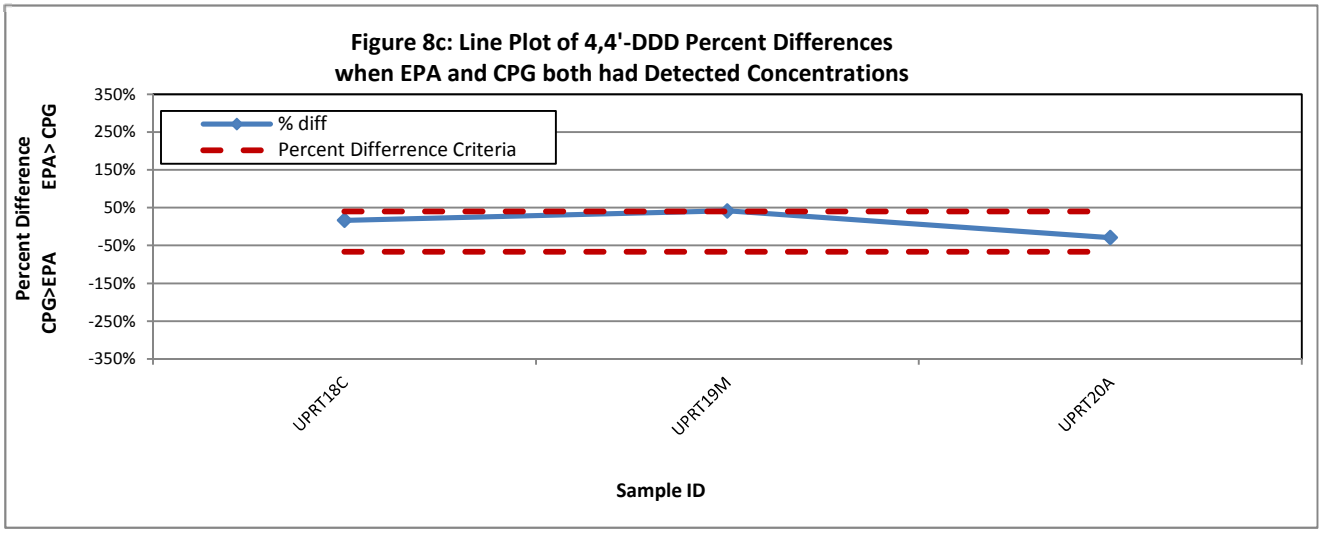
**Figure 7**

Total TCDD = total tetrachlorodibenzo-p-dioxin

CDM Smith




| | | |
|---|---|---|
| US Army Corps of Engineers® | **Statistical Plot of Sediment 4,4'-DDD Concentrations** | **Figure 8** |

4,4'-DDD = 4,4'-dichlorodiphenyldichloroethane

CDM Smith

**Figure 9a: Line Plot of 4,4'-DDE Concentrations**

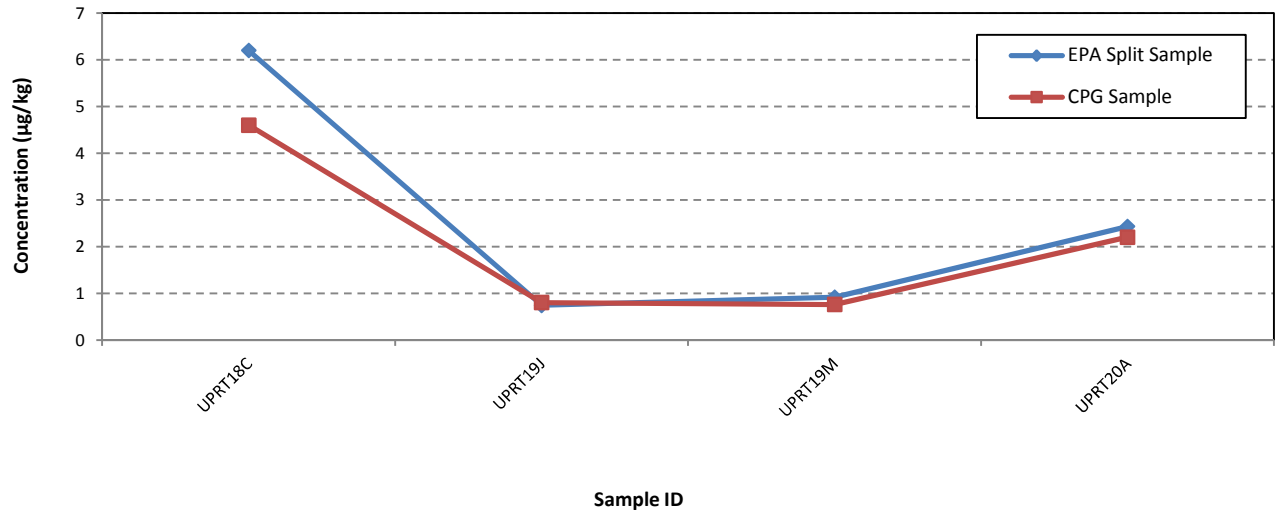



**Figure 9b: Bivariate Plot of 4,4'-DDE Concentrations**

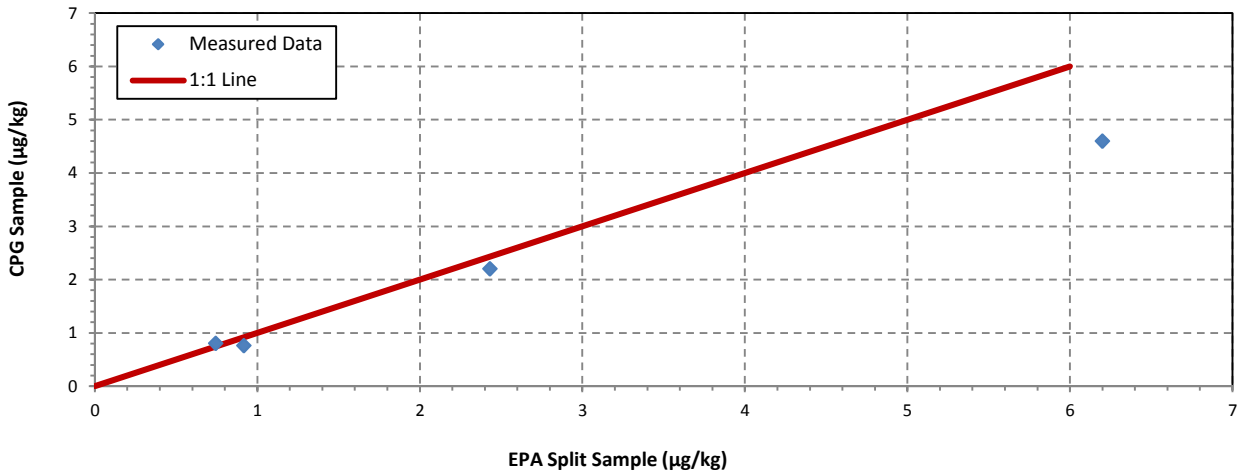
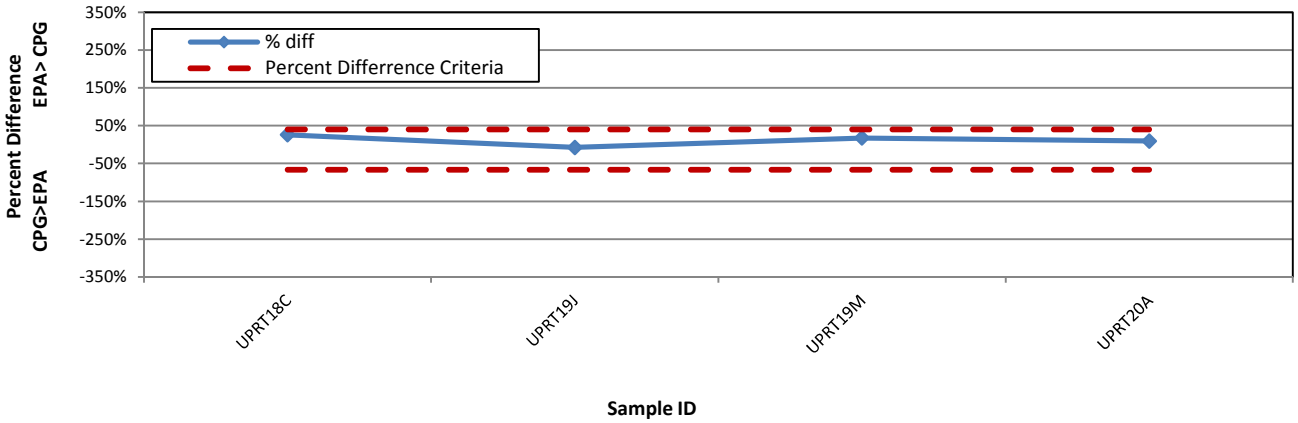



**Figure 9c: Line Plot of 4,4'-DDE Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers®

**Statistical Plot of Sediment 4,4'-DDE Concentrations**

**Figure 9**

4,4'-DDE = 4,4'-dichlorodiphenyldichloroethylene

CDM Smith

**Figure 10a: Line Plot of 4,4'-DDT Concentrations**

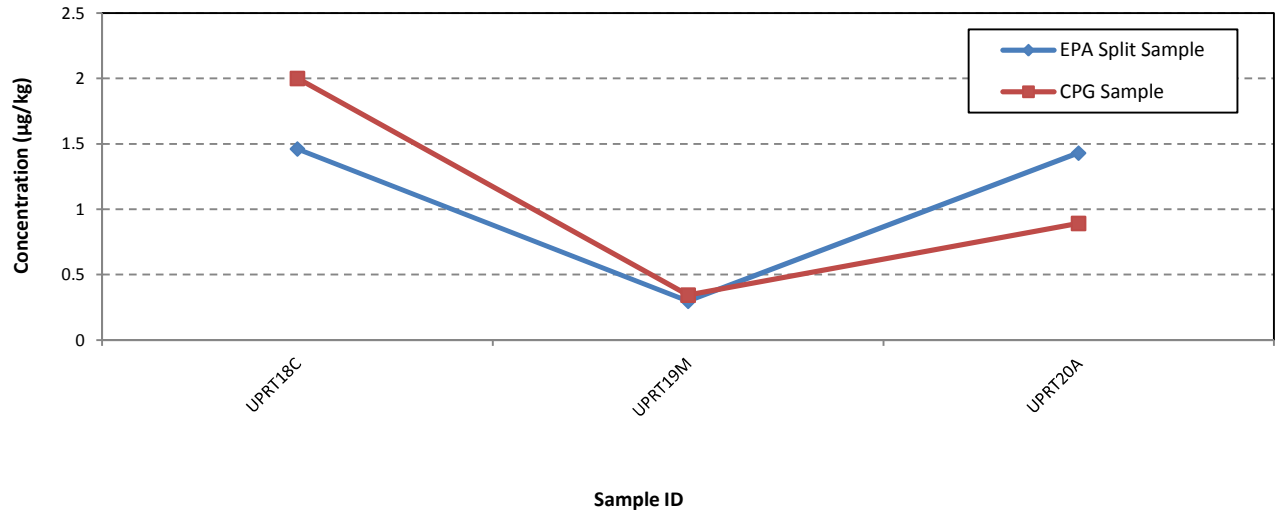



**Figure 10b: Bivariate Plot of 4,4'-DDT Concentrations**

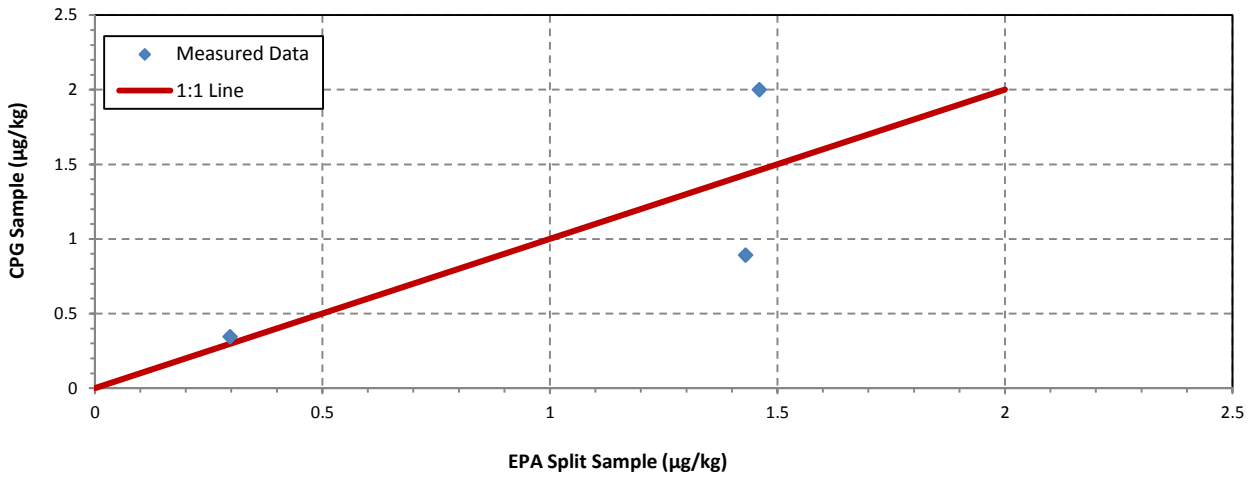
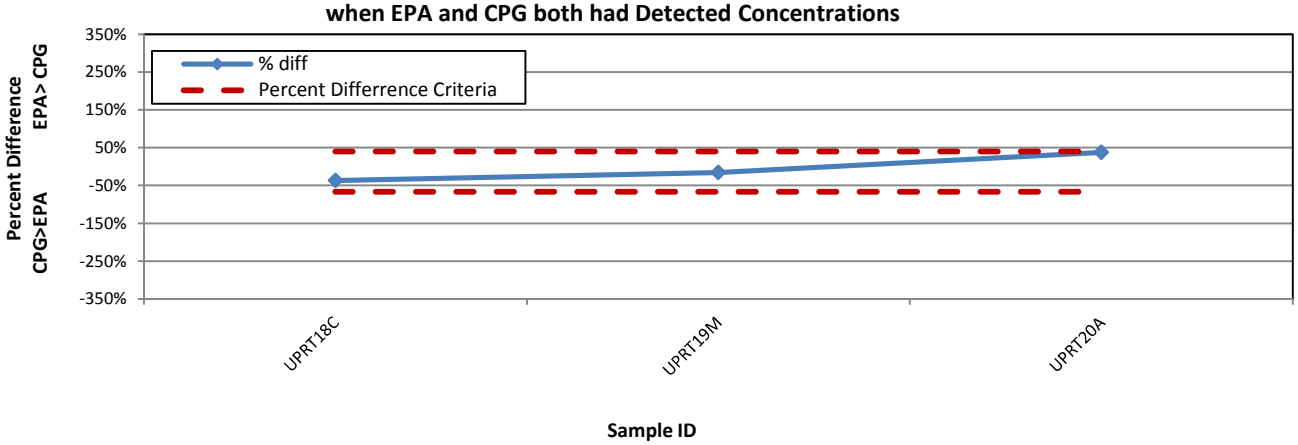



**Figure 10c: Line Plot of 4,4'-DDT Percent Differences when EPA and CPG both had Detected Concentrations**




| US Army Corps of Engineers | Statistical Plot of Sediment 4,4'-DDT Concentrations | Figure 10 |
|---|---|---|

4,4'-DDT = 4,4'-dichlorodiphenyltrichloroethane

CDM Smith

**Figure 11a: Line Plot of Dieldrin Concentrations**

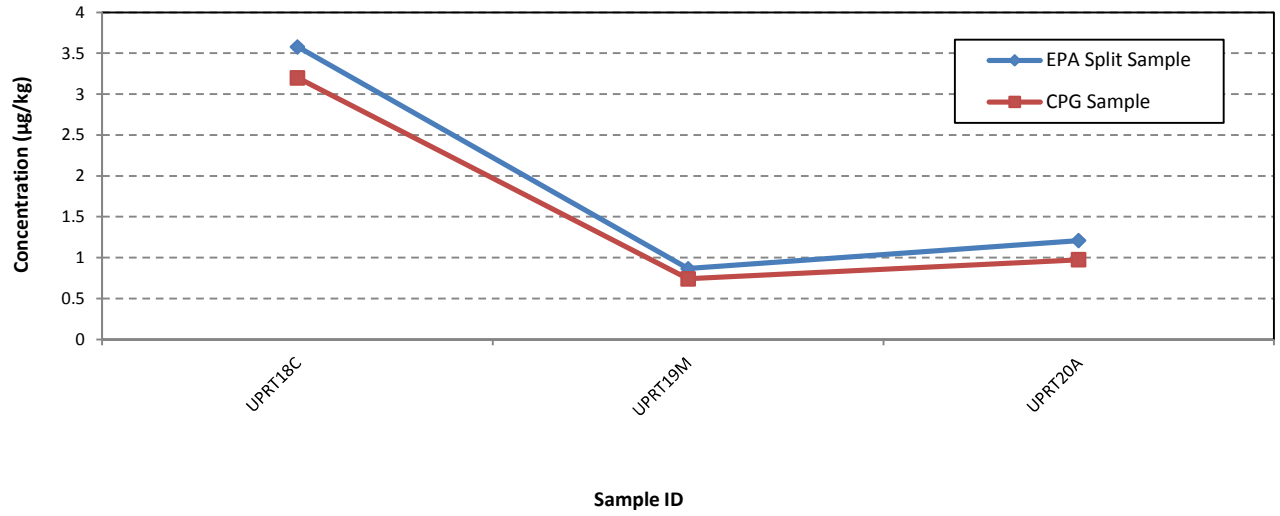



**Figure 11b: Bivariate Plot of Dieldrin Concentrations**

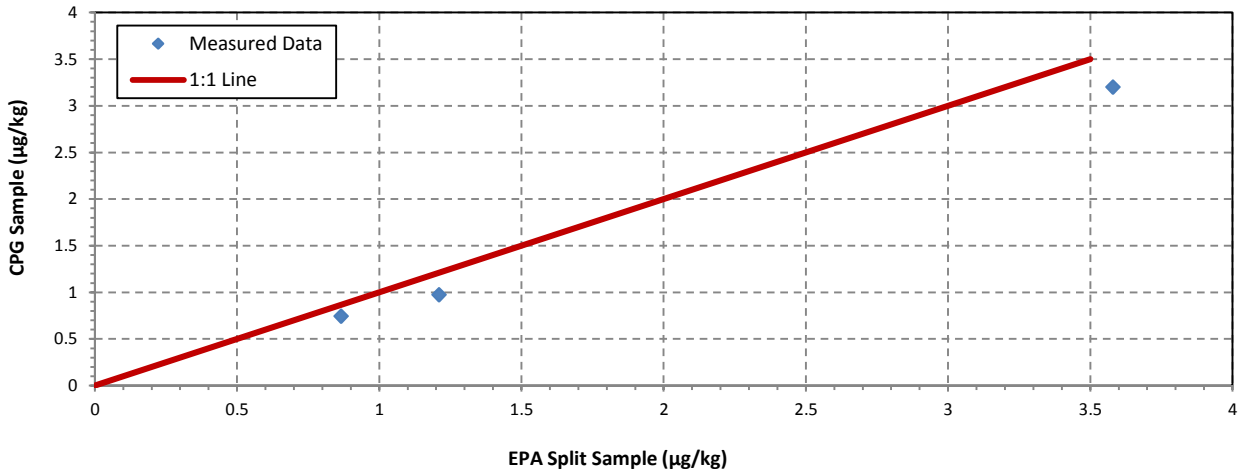
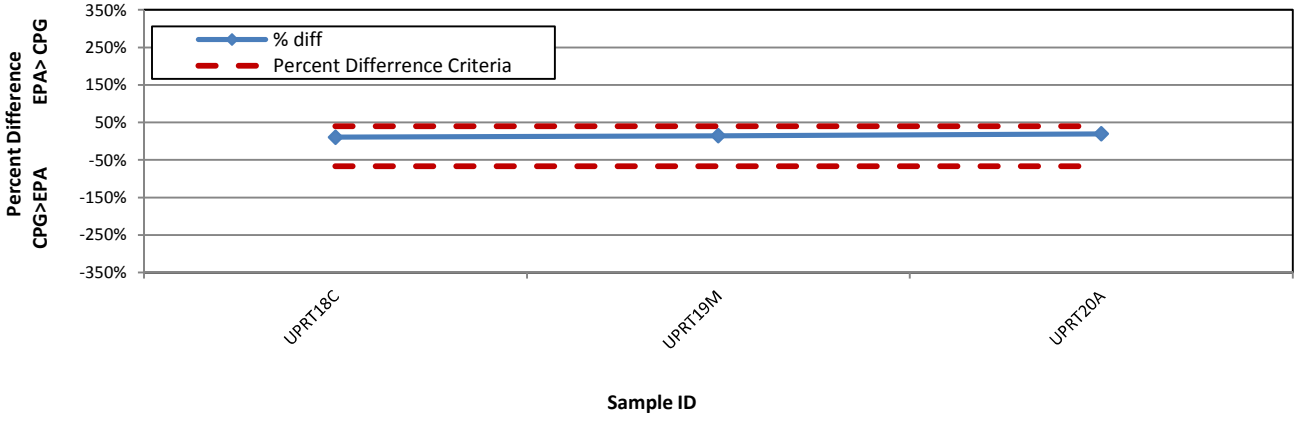



**Figure 11c: Line Plot of Dieldrin Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Dieldrin Concentrations**

**Figure 11**

CDM Smith

**Figure 12a: Line Plot of alpha-Chlordane Concentrations**

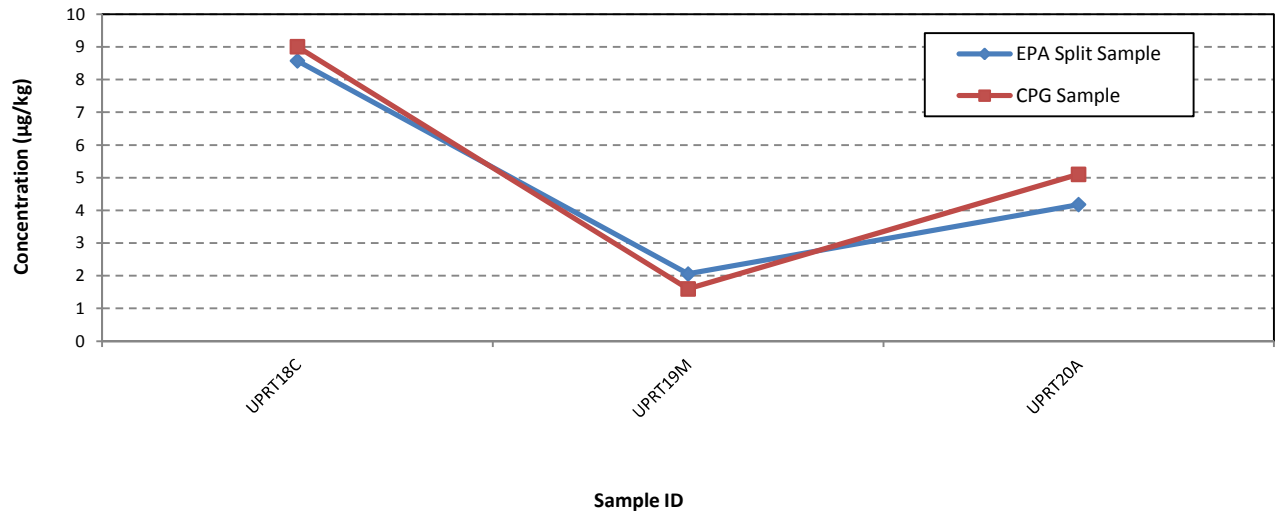



**Figure 12b: Bivariate Plot of alpha-Chlordane Concentrations**

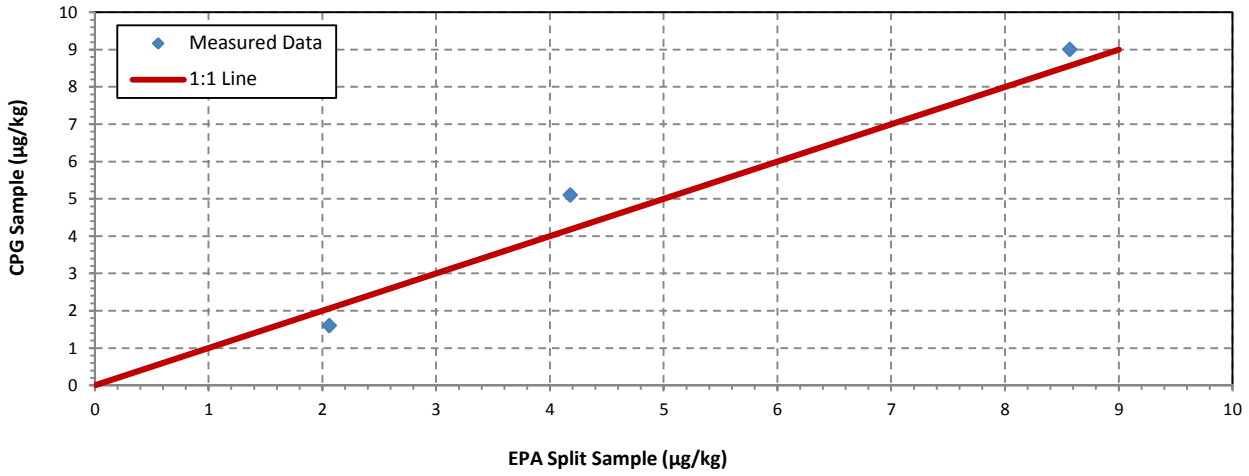
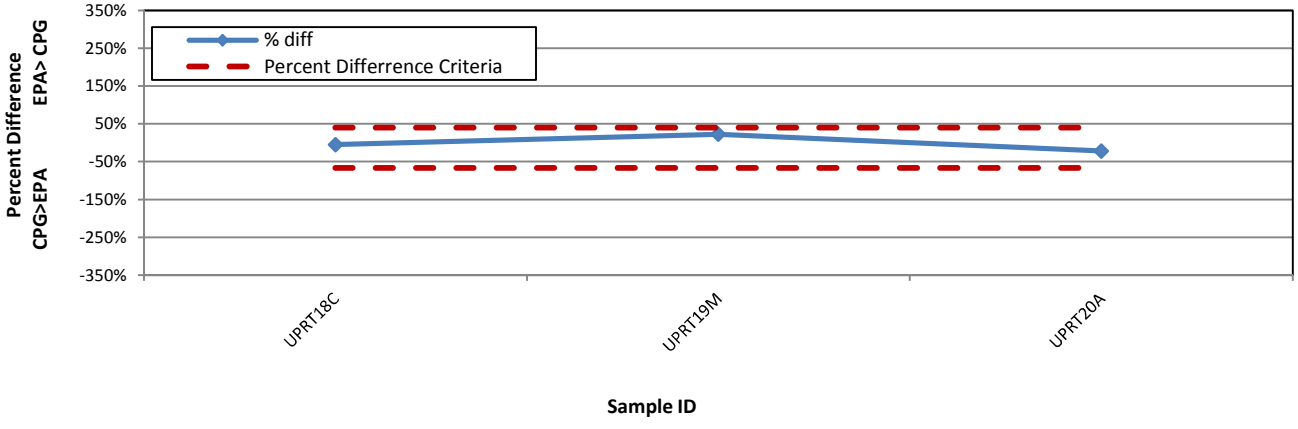



**Figure 12c: Line Plot of alpha-Chlordane Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment gamma-Chlordane Concentrations**

**Figure 12**

CDM Smith

**Figure 13a: Line Plot of 2,4'-DDD Concentrations**

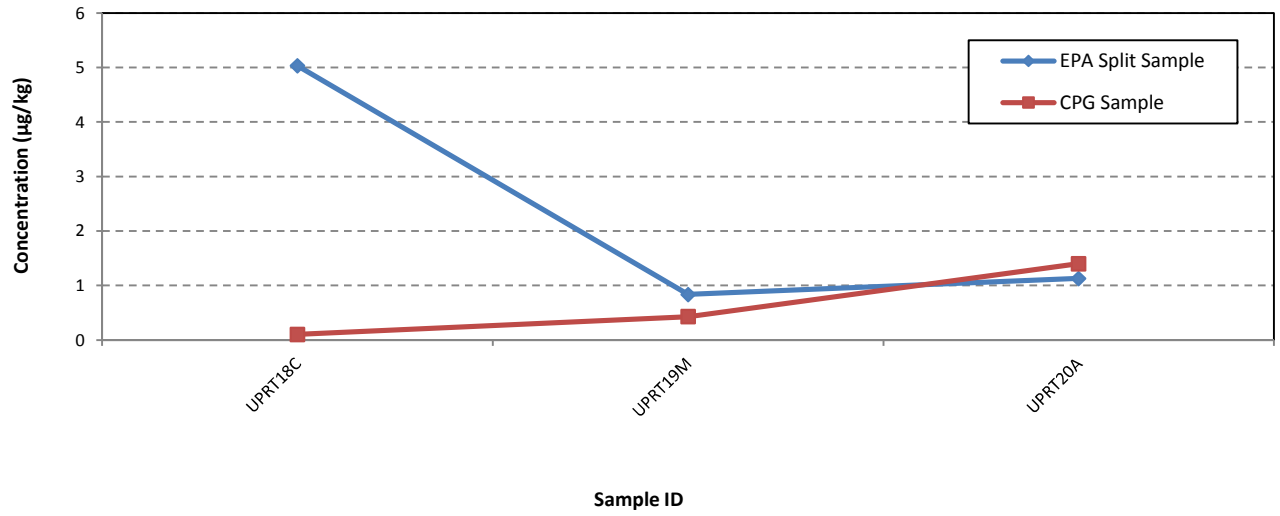



**Figure 13b: Bivariate Plot of 2,4'-DDD Concentrations**

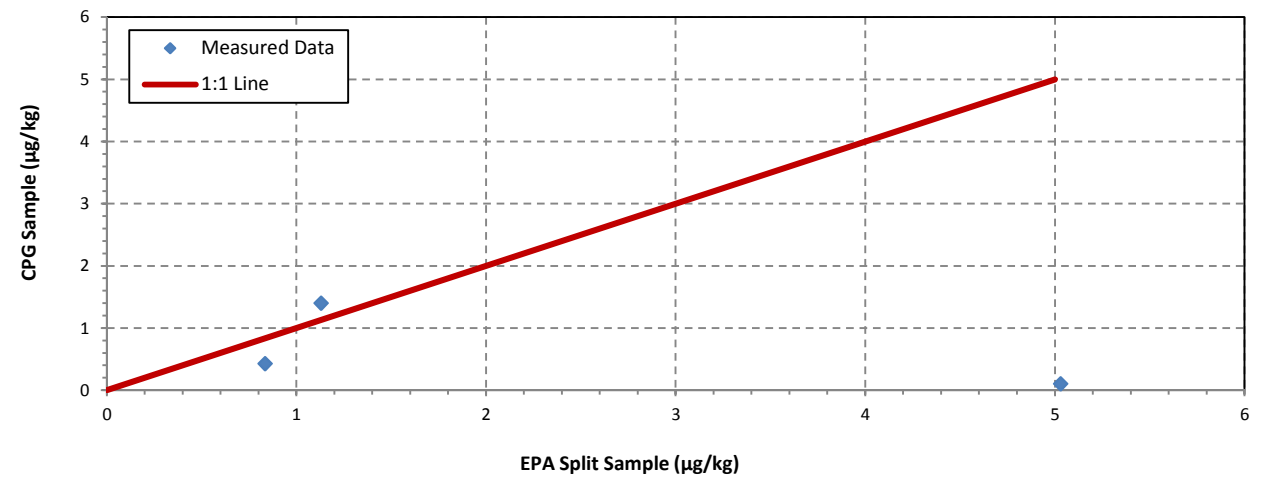
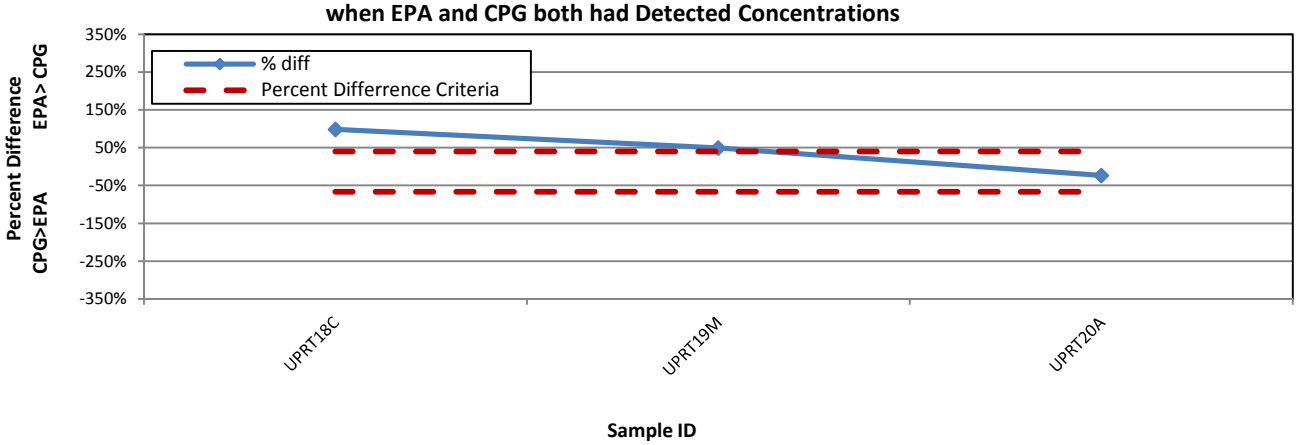



**Figure 13c: Line Plot of 2,4'-DDD Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 2,4'-DDD Concentrations** | **Figure 13**

2,4'-DDD = 2,4'-dichlorodiphenyldichloroethane

CDM Smith

**Figure 14a: Line Plot of 2,4'-DDE Concentrations**

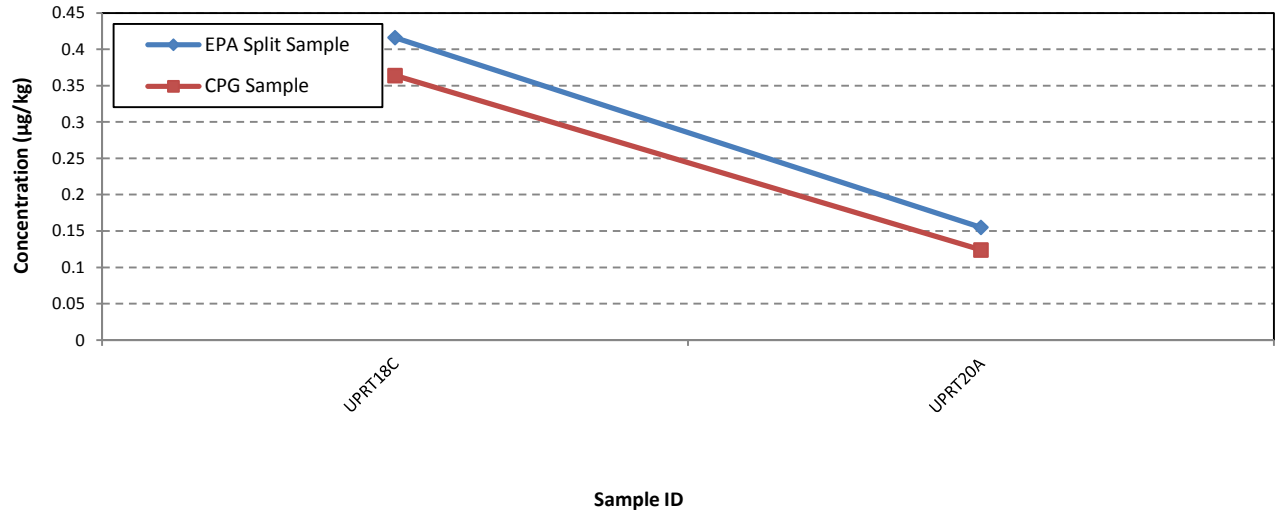



**Figure 14b: Bivariate Plot of 2,4'-DDE Concentrations**

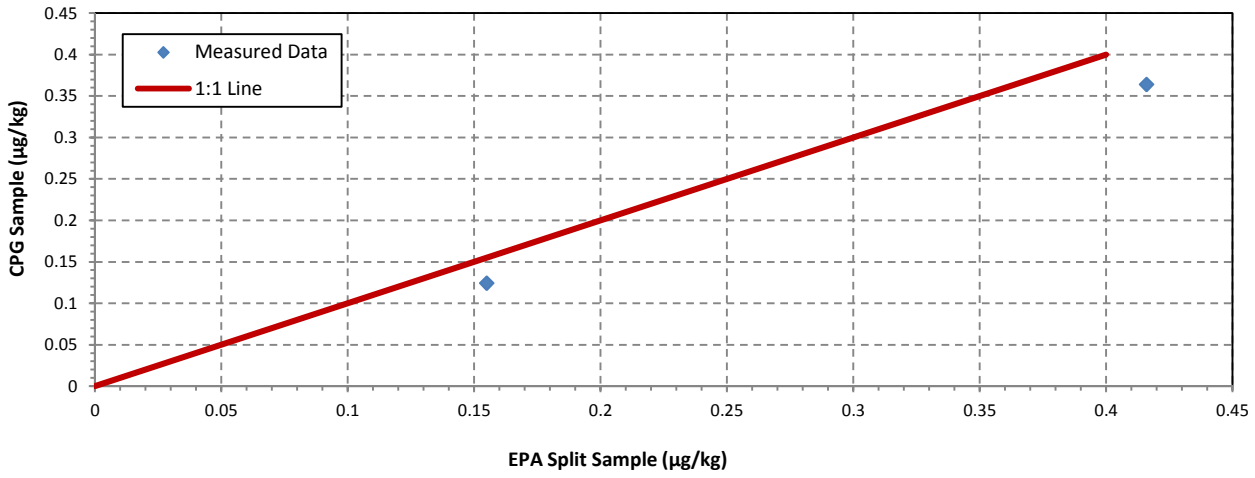
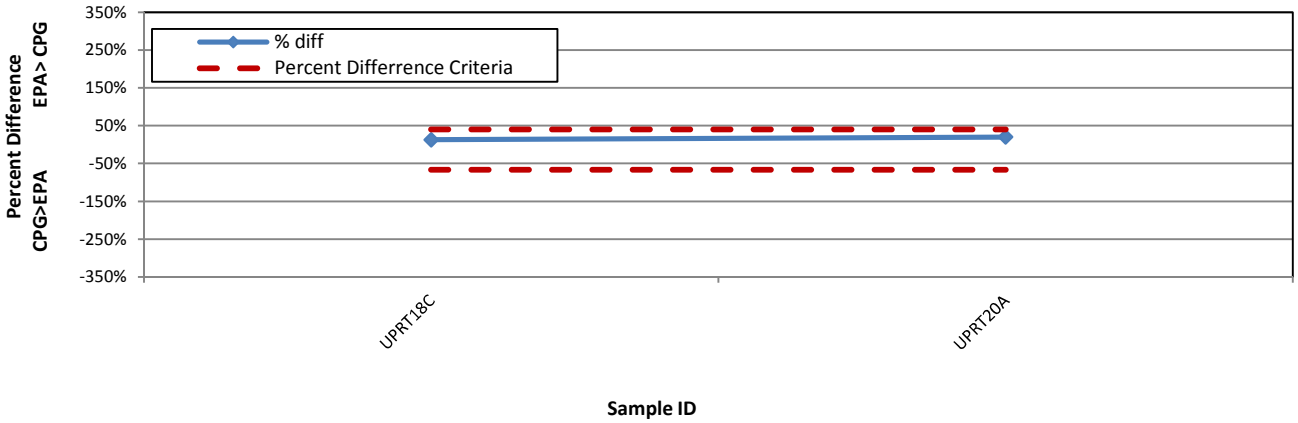



**Figure 14c: Line Plot of 2,4'-DDE Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers® | **Statistical Plot of Sediment 2,4'-DDE Concentrations** | **Figure 14** |

2,4'-DDE = 2,4'-dichlorodiphenyldichloroethylene

CDM Smith

**Figure 15a: Line Plot of 2,4'-DDT Concentrations**

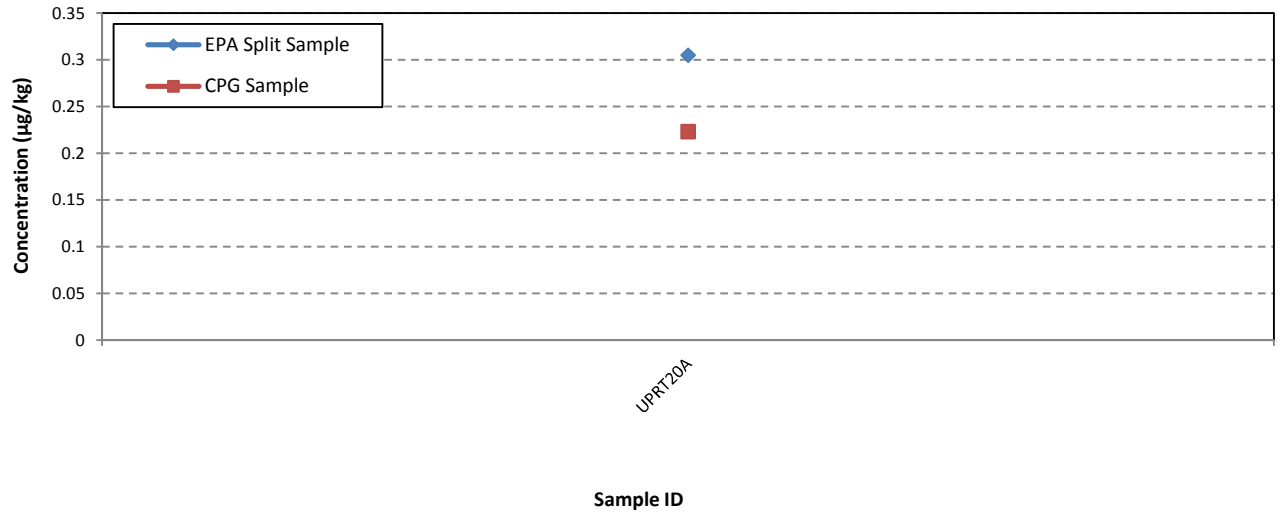



**Figure 15b: Bivariate Plot of 2,4'-DDT Concentrations**

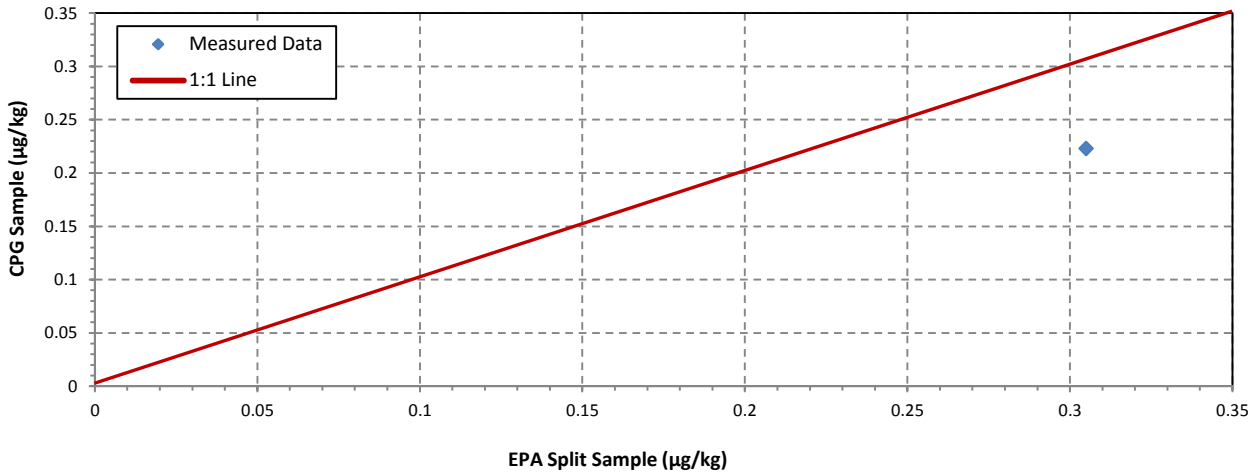
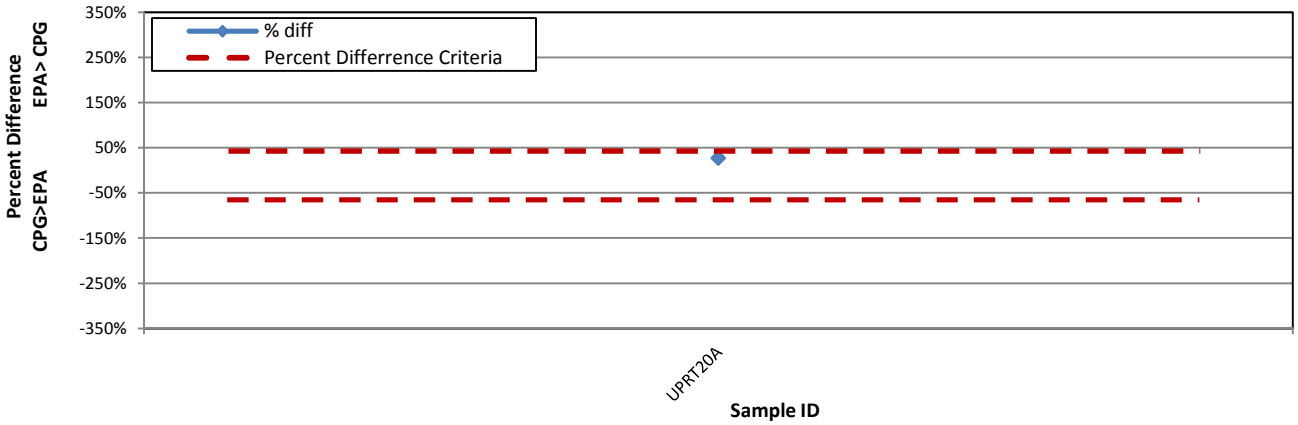



**Figure 15c: Line Plot of 2,4'-DDT Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 2,4'-DDT Concentrations**

**Figure 15**

2,4'-DDT = 2,4'-dichlorodiphenyltrichloroethane

CDM Smith

**Figure 16a: Line Plot of 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Concentrations**

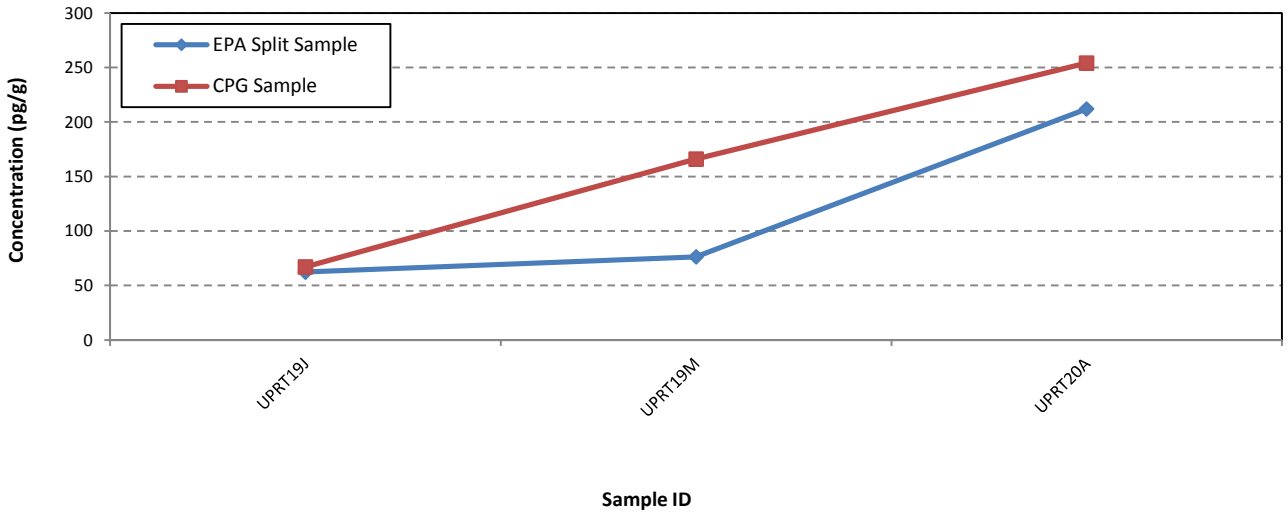



**Figure 16b: Bivariate Plot of 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Concentrations**

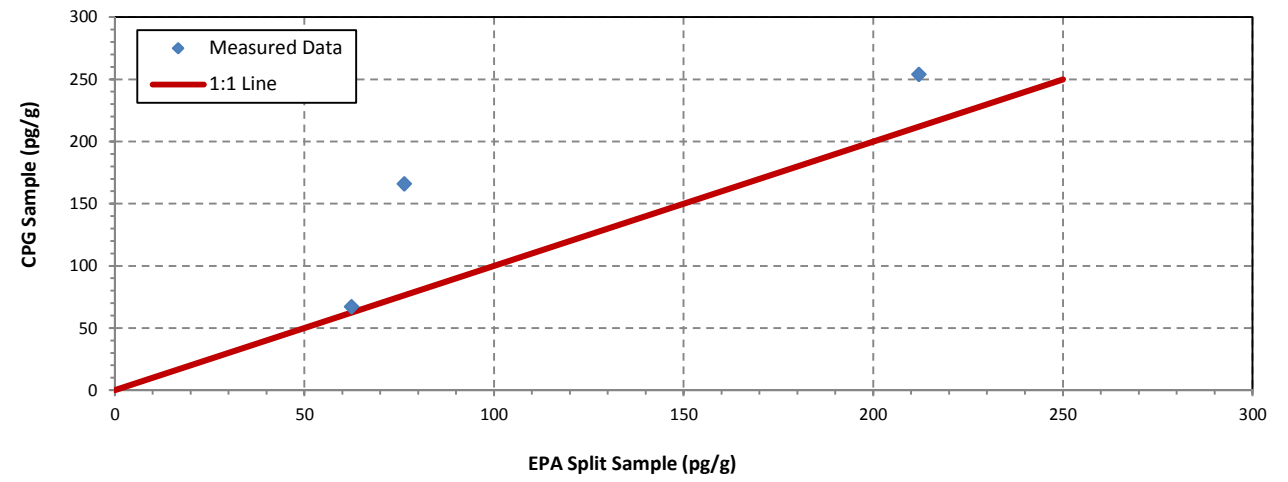
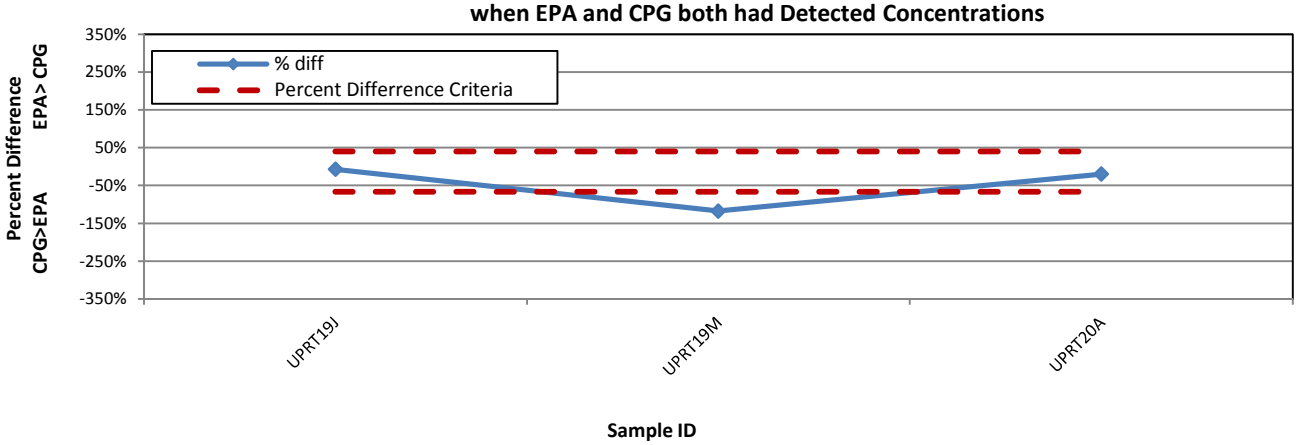



**Figure 16c: Line Plot of 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 3,3',4,4'-Tetrachlorobiphenyl (PCB 77) Concentrations**

**Figure 16**

PCB = polychlorinated biphenyl

CDM Smith

**Figure 17a: Line Plot of 3,4,4',5-Tetrachlorobiphenyl (PCB 81) Concentrations**

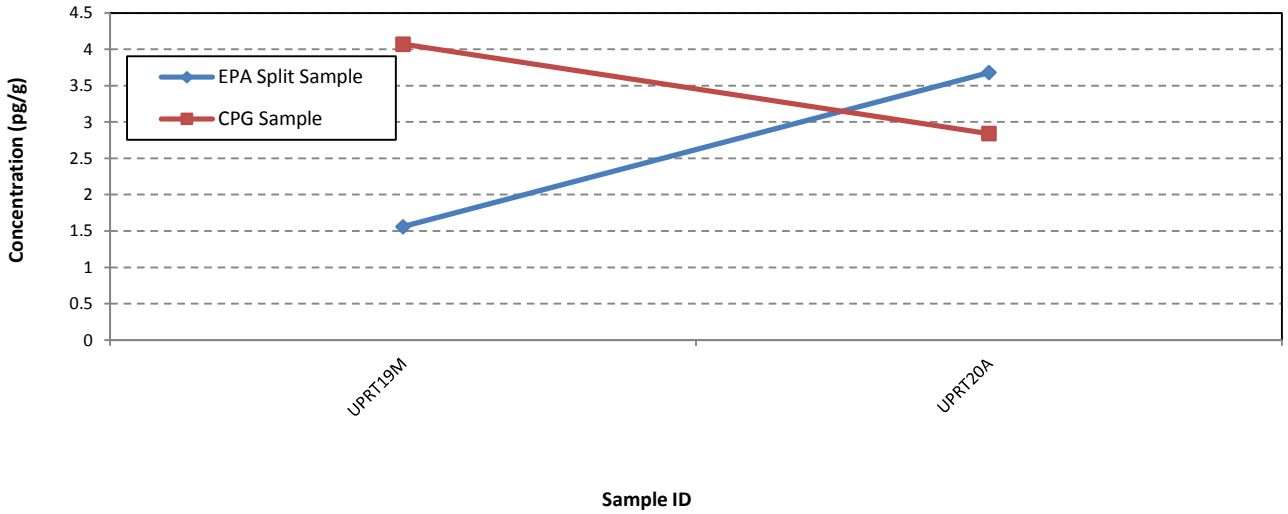



**Figure 17b: Bivariate Plot of 3,4,4',5-Tetrachlorobiphenyl (PCB 81) Concentrations**

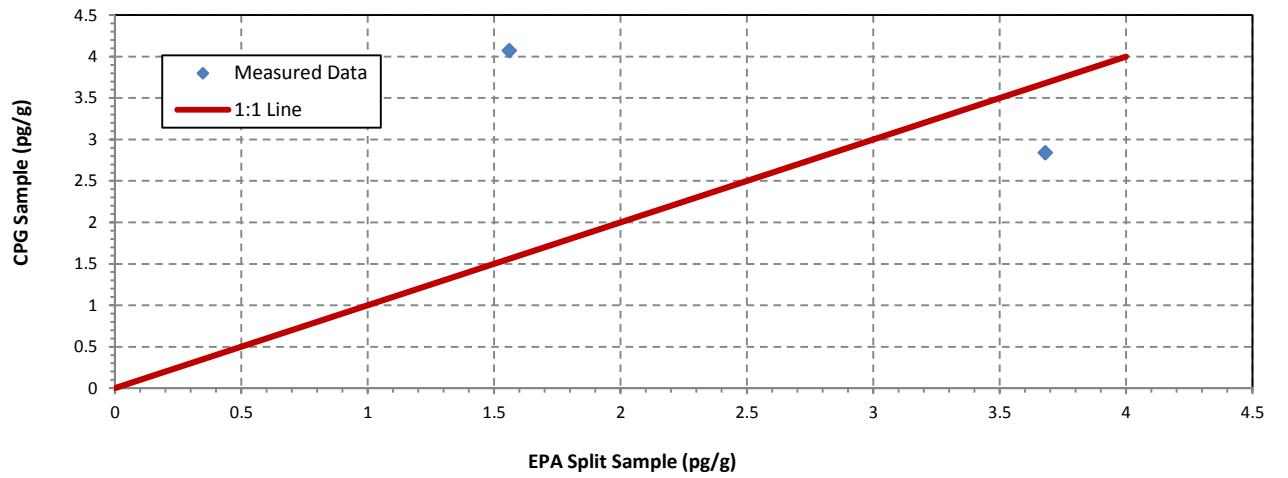
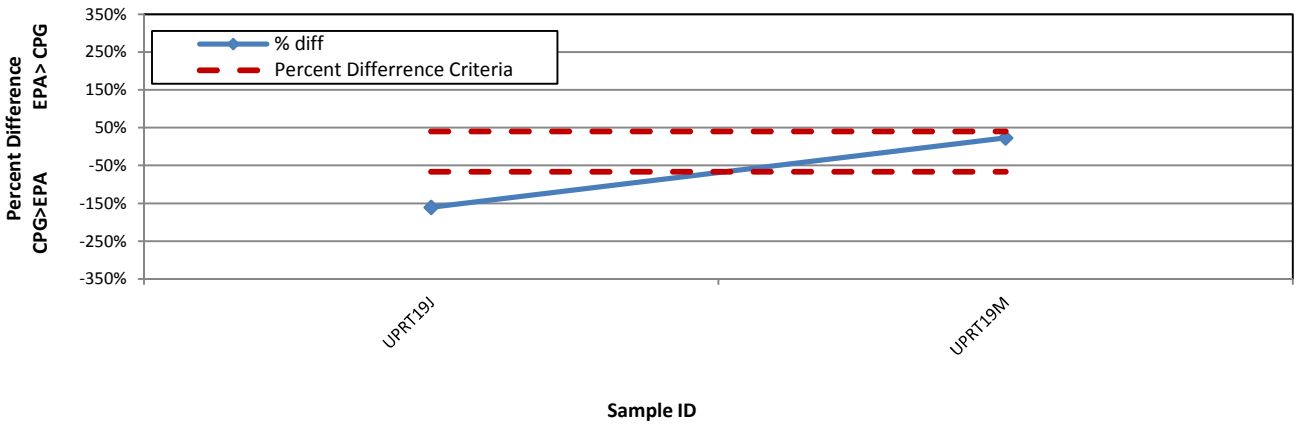



**Figure 17c: Line Plot of 3,4,4',5-Tetrachlorobiphenyl (PCB 81) Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers® | **Statistical Plot of Sediment 3,4,4',5-Tetrachlorobiphenyl (PCB 81) Concentrations** | **Figure 17** |

PCB = polychlorinated biphenyl

CDM Smith

**Figure 18a: Line Plot of 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Concentrations**

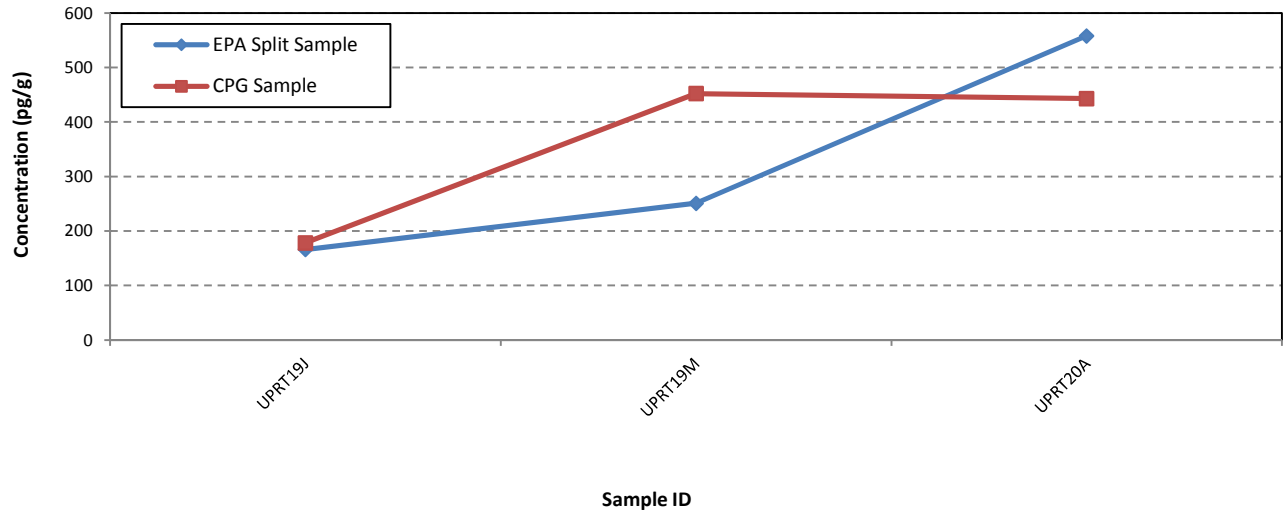



**Figure 18b: Bivariate Plot of 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Concentrations**

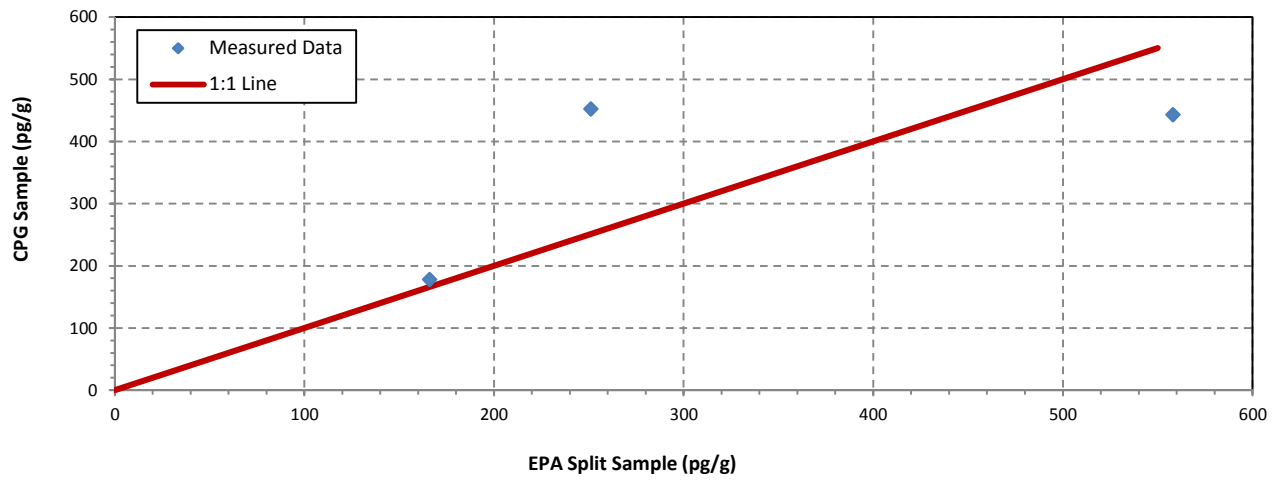
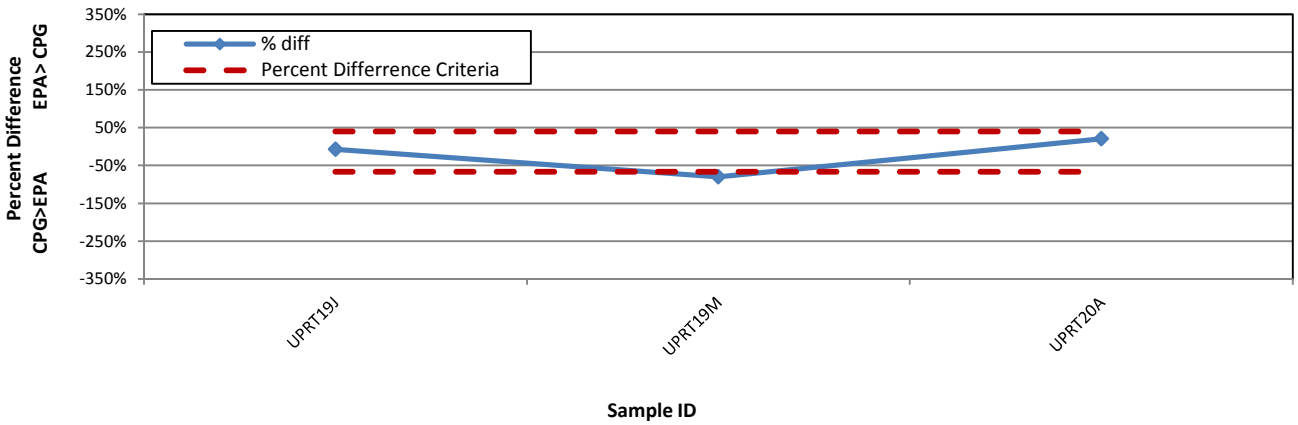



**Figure 18c: Line Plot of 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Percent Differences when EPA and CPG both had Detected Concentrations**

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|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) Concentrations** | **Figure 18** |

PCB = polychlorinated biphenyl

CDM Smith

**Figure 19a: Line Plot of 2,3,4,4',5-Pentachlorobiphenyl (PCB 114) Concentrations**

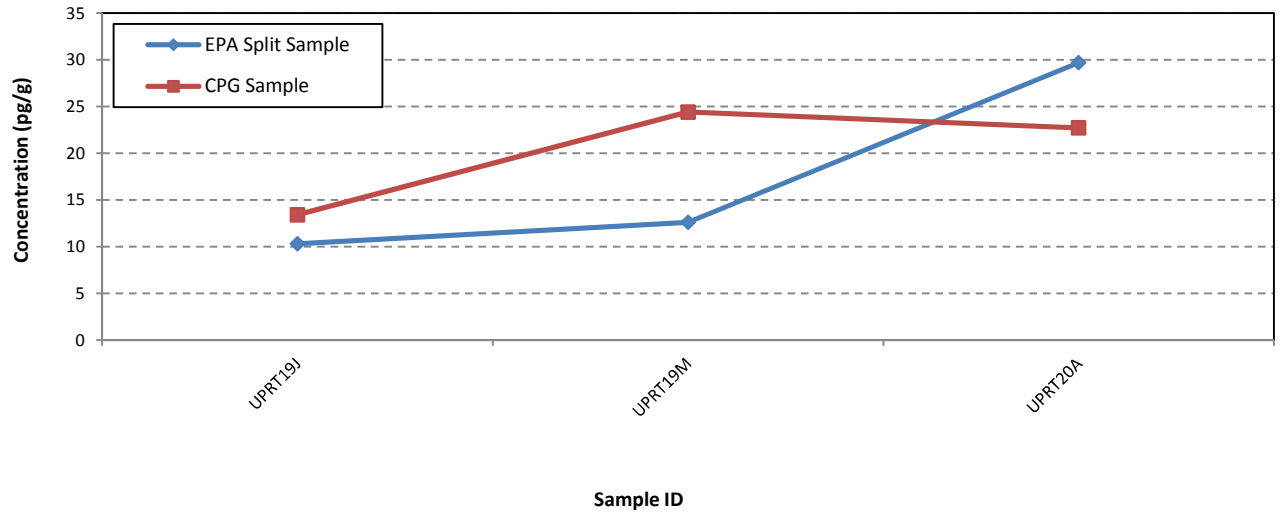



**Figure 19b: Bivariate Plot of 2,3,4,4',5-Pentachlorobiphenyl (PCB 114) Concentrations**

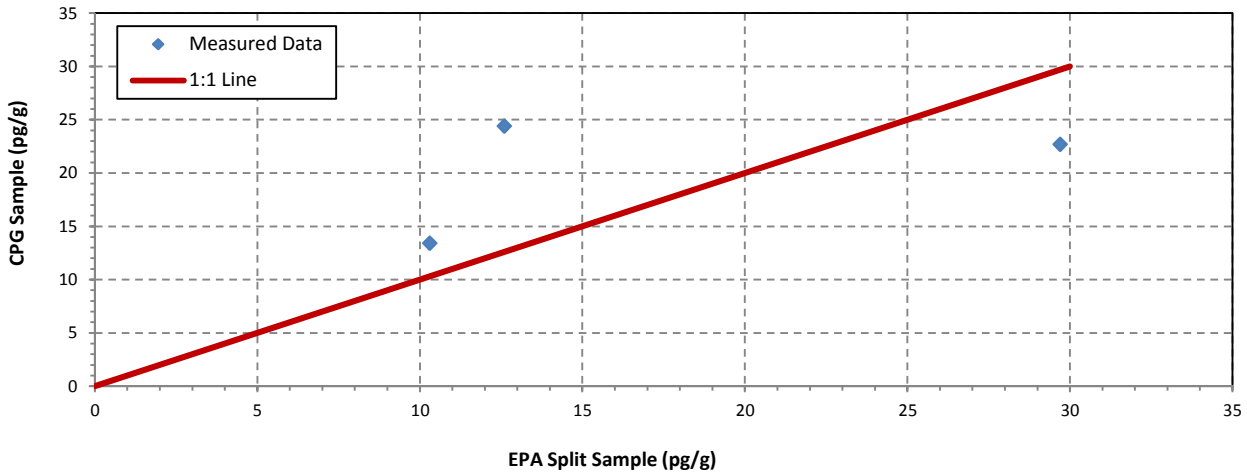
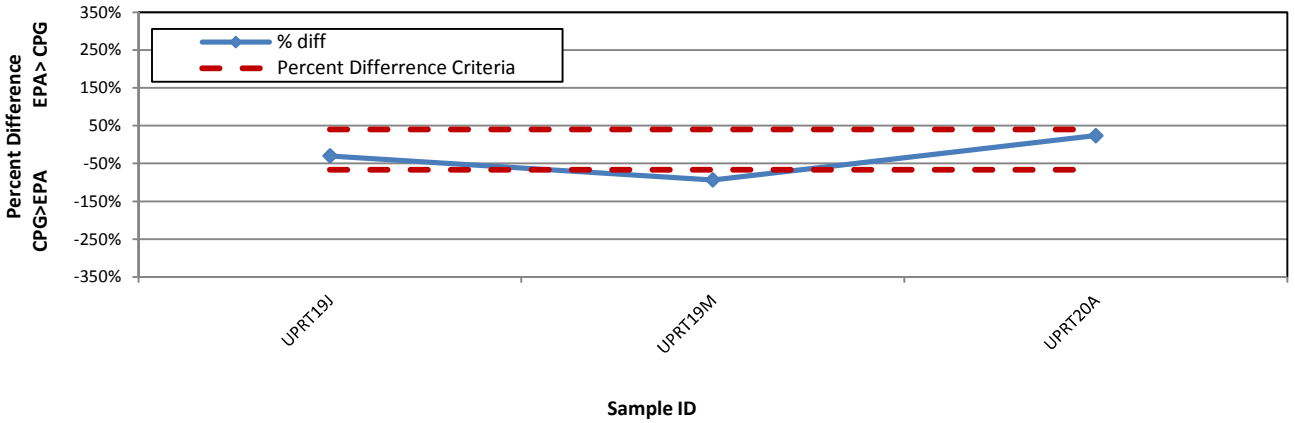



**Figure 19c: Line Plot of 2,3,4,4',5-Pentachlorobiphenyl (PCB 114) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 2,3,4,4',5-Pentachlorobiphenyl (PCB 114) Concentrations**

**Figure 19**

PCB = polychlorinated biphenyl

CDM Smith

**Figure 20a: Line Plot of 2,3',4,4',5-Pentachlorobiphenyl (PCB 118) Concentrations**

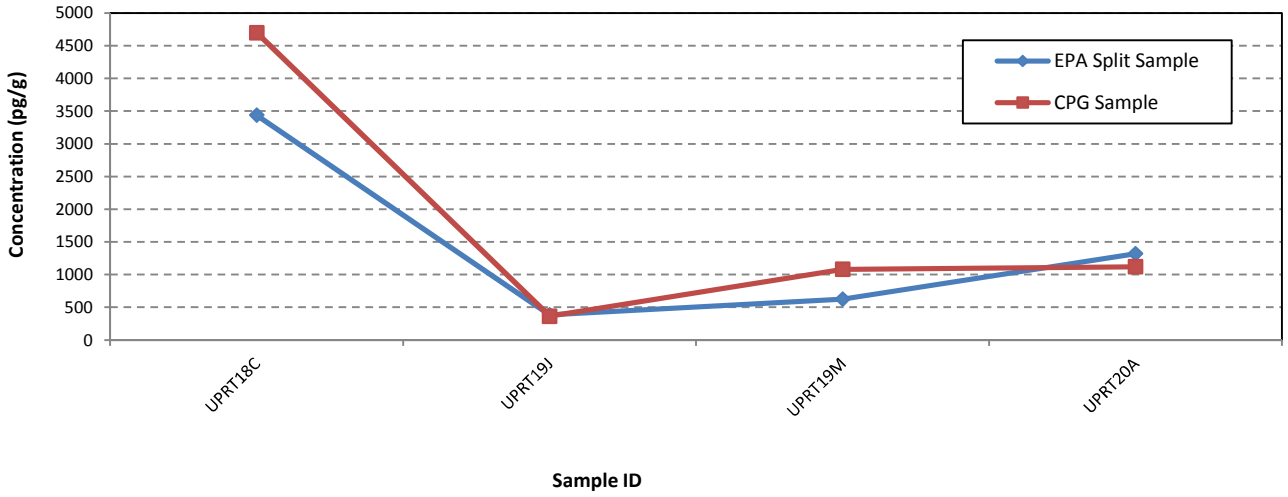



**Figure 20b: Bivariate Plot of 2,3',4,4',5-Pentachlorobiphenyl (PCB 118) Concentrations**

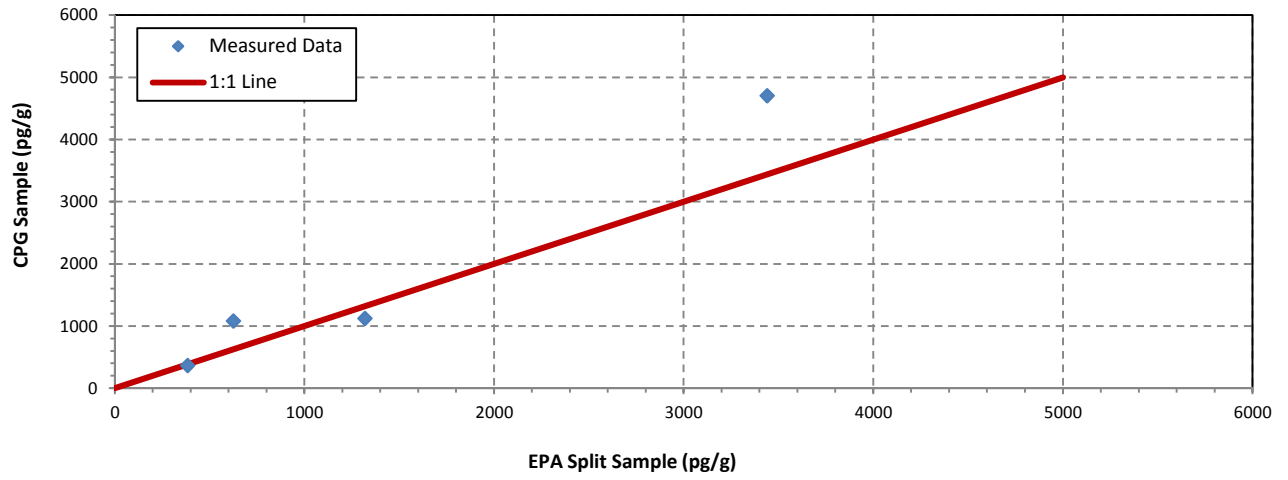
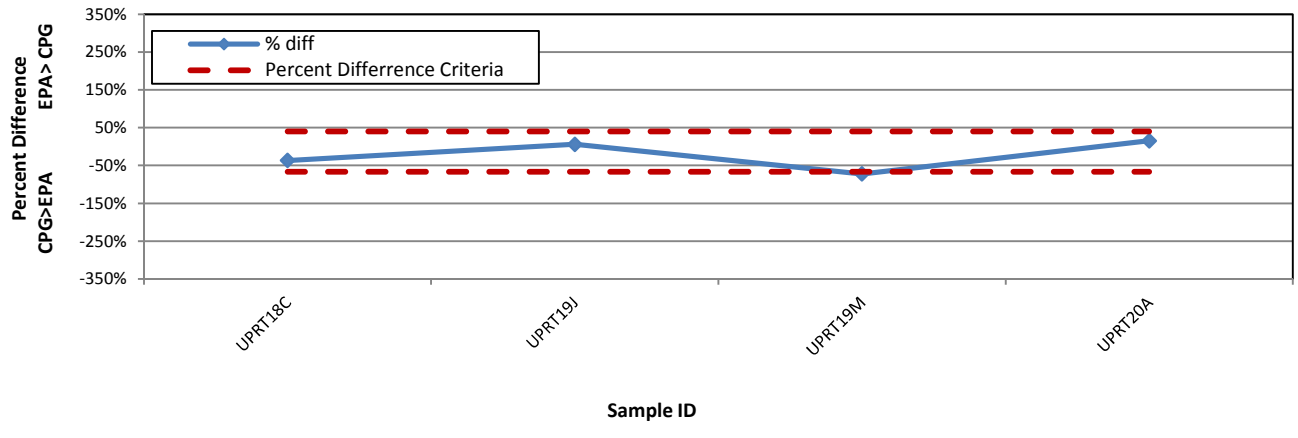



**Figure 20c: Line Plot of 2,3',4,4',5-Pentachlorobiphenyl (PCB 118) Percent Differences when EPA and CPG both had Detected Concentrations**

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|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment 2,3',4,4',5-Pentachlorobiphenyl (PCB 118) Concentrations** | **Figure 20** |

PCB = polychlorinated biphenyl

CDM Smith

**Figure 21a: Line Plot of 2',3,4,4',5-Pentachlorobiphenyl (PCB 123) Concentrations**

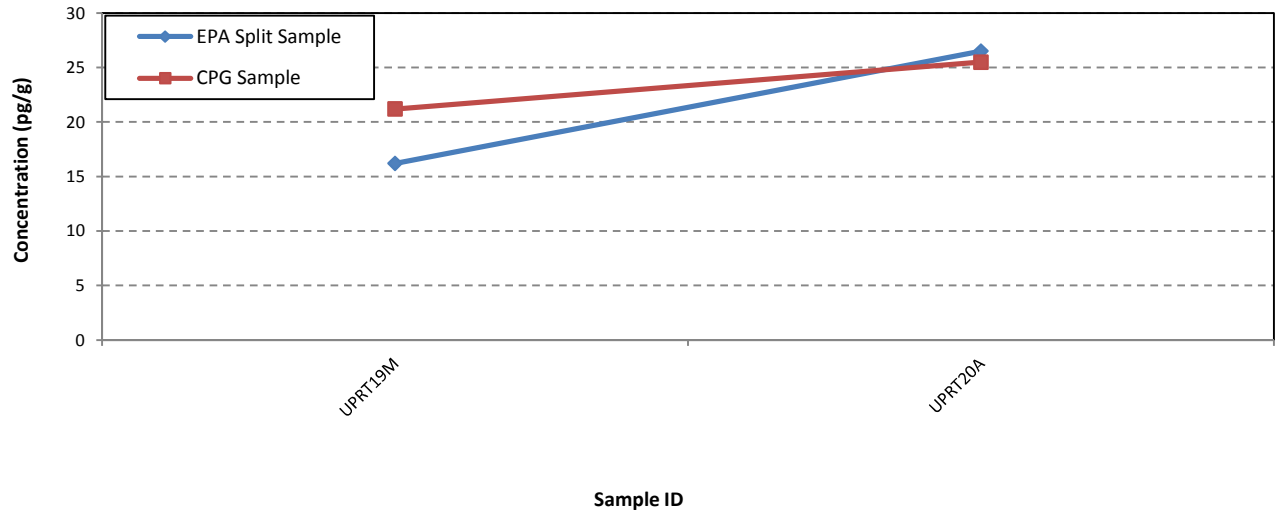



**Figure 21b: Bivariate Plot of 2',3,4,4',5-Pentachlorobiphenyl (PCB 123) Concentrations**

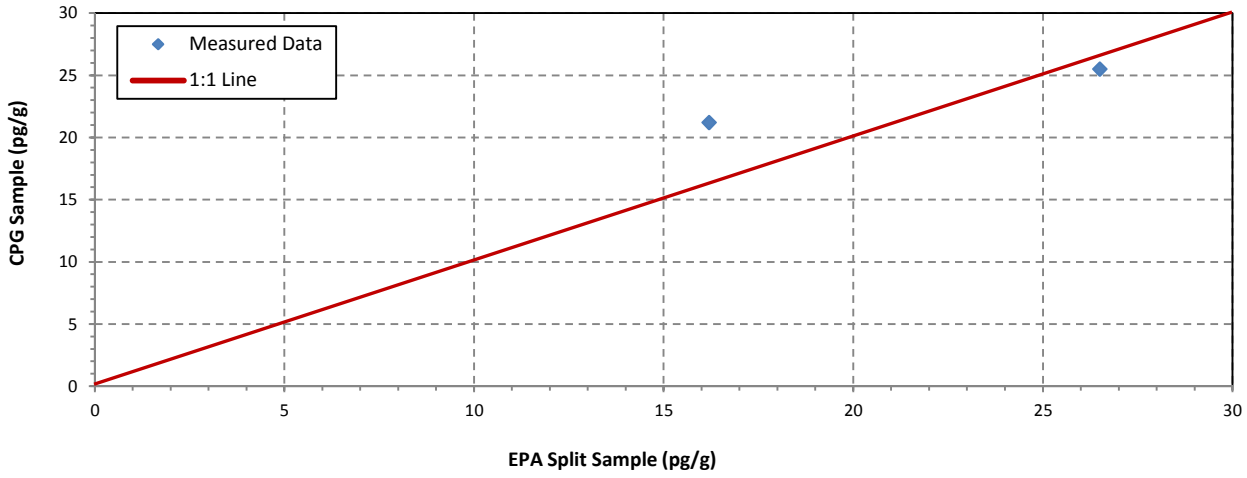
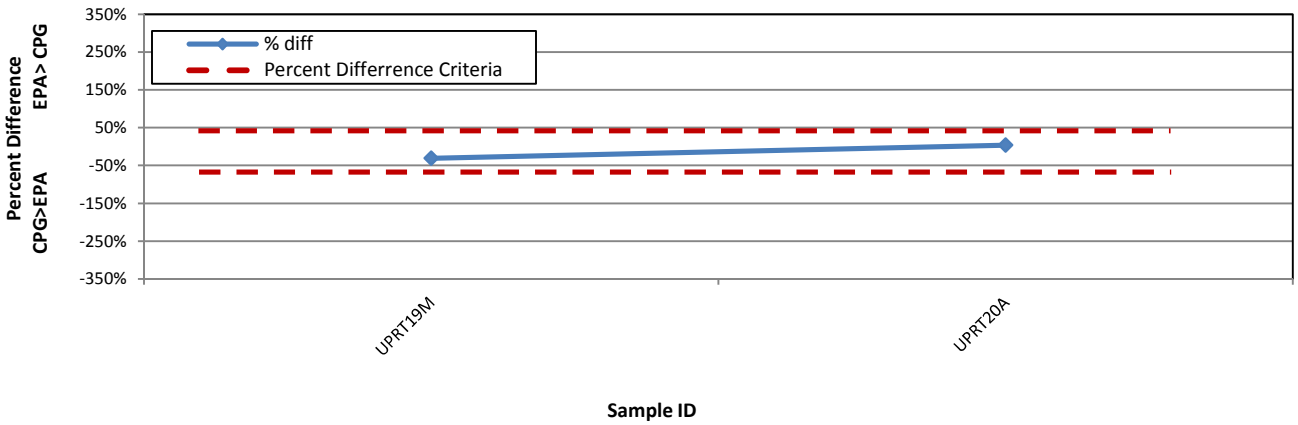



**Figure 21c: Line Plot of 2',3,4,4',5-Pentachlorobiphenyl (PCB 123) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 2,3',4,4',5'-Pentachlorobiphenyl (PCB 123) Concentrations**

**Figure 21**

PCB = polychlorinated biphenyl

CDM Smith

**Figure 22a: Line Plot of 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Concentrations**

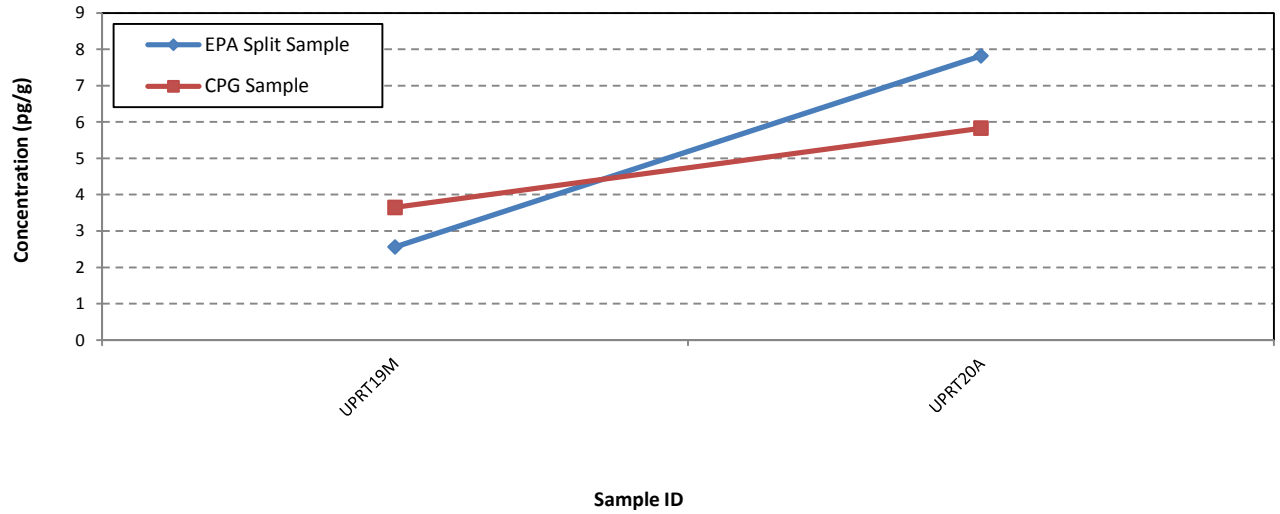



**Figure 22b: Bivariate Plot of 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Concentrations**

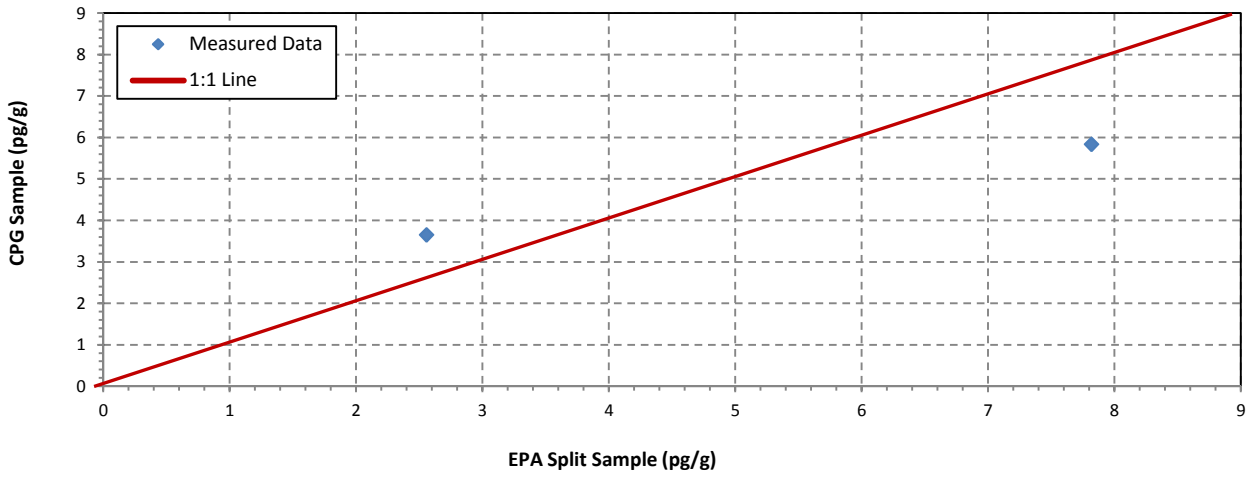
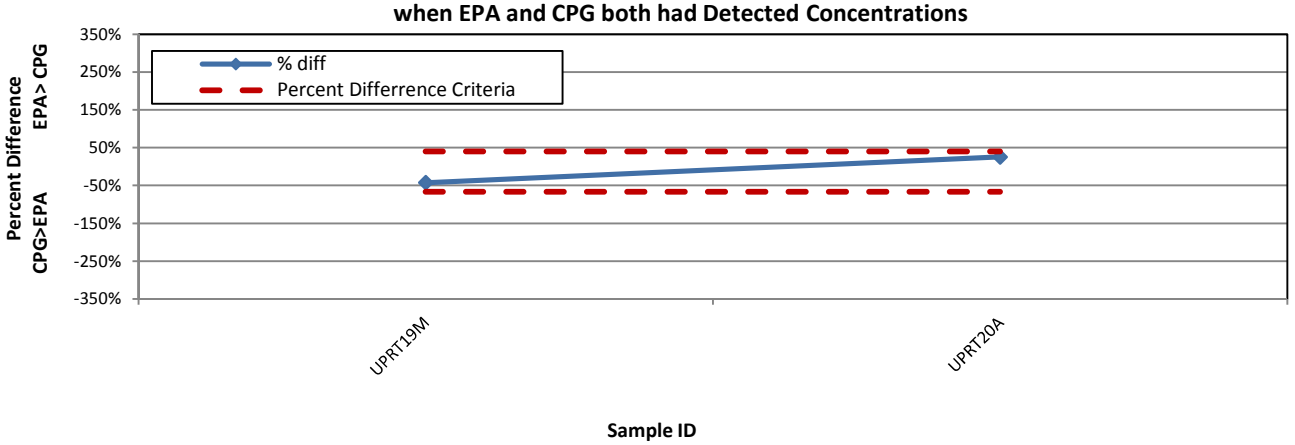



**Figure 22c: Line Plot of 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Percent Differences when EPA and CPG both had Detected Concentrations**

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|---|---|---|
| US Army Corps of Engineers® | **Statistical Plot of Sediment 3,3',4,4',5-Pentachlorobiphenyl (PCB 126) Concentrations** | **Figure 22** |

PCB = polychlorinated biphenyl

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**Figure 23a: Line Plot of 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Concentrations**

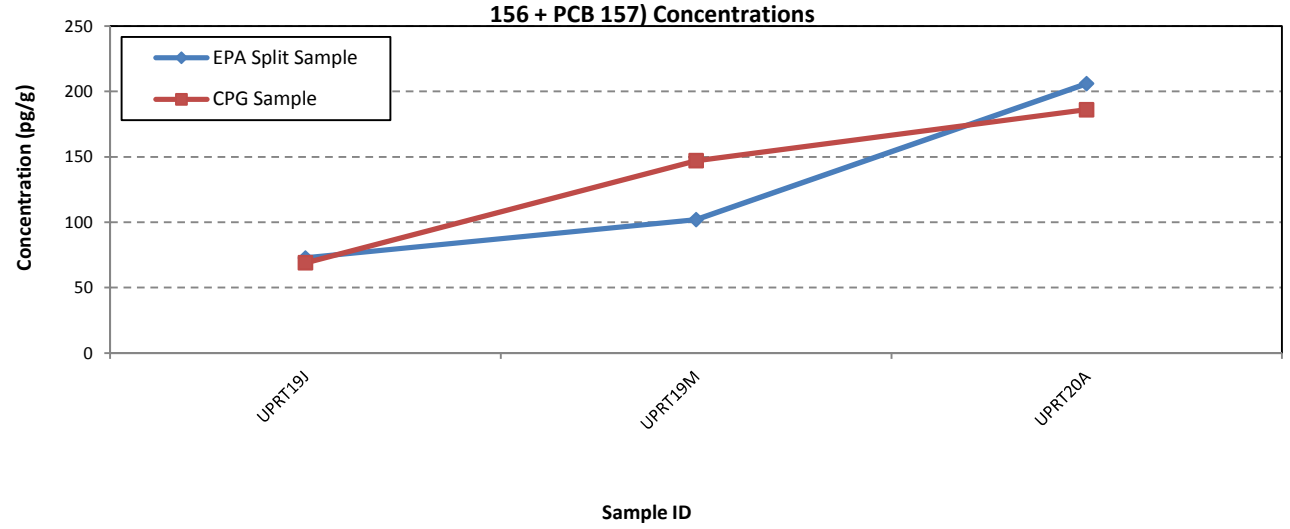



**Figure 23b: Bivariate Plot of 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Concentrations**

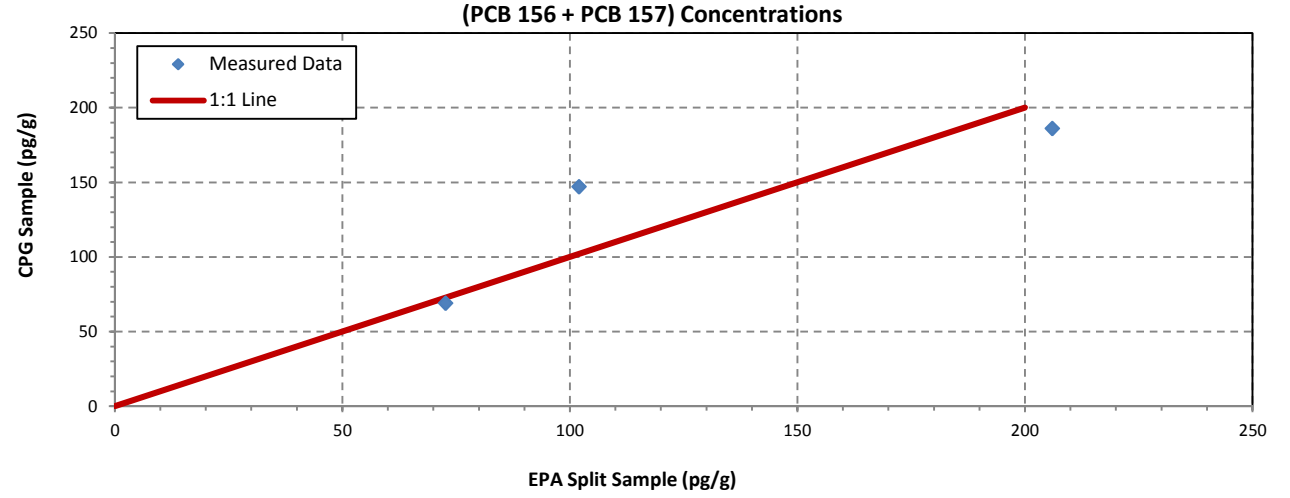
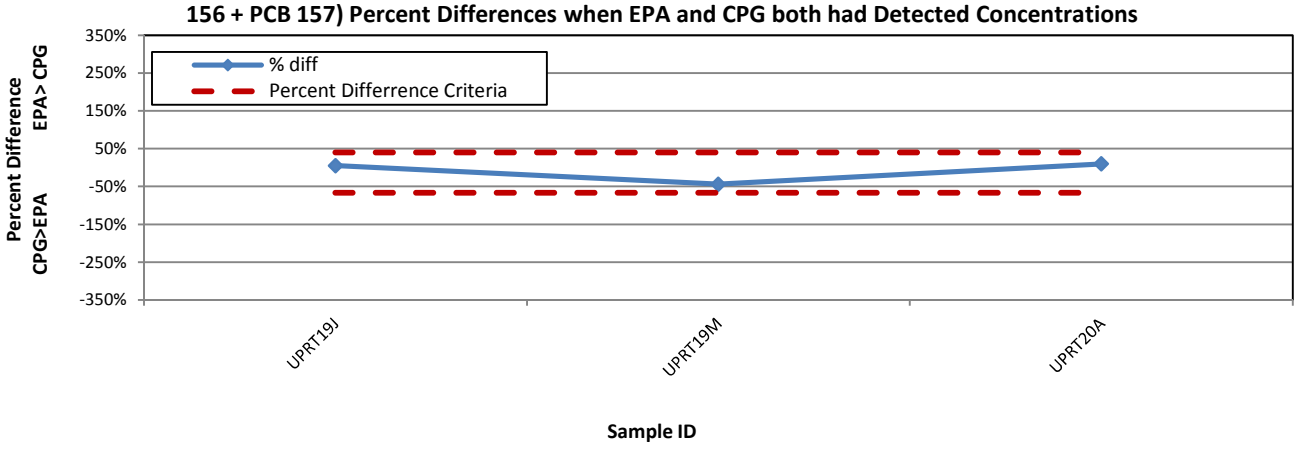



**Figure 23c: Line Plot of 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 2,3,3',4,4',5-Hexachlorobiphenyl + 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 156 + PCB 157) Concentrations**

**Figure 23**

PCB = polychlorinated biphenyl

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**Figure 24a: Line Plot of 2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167) Concentrations**

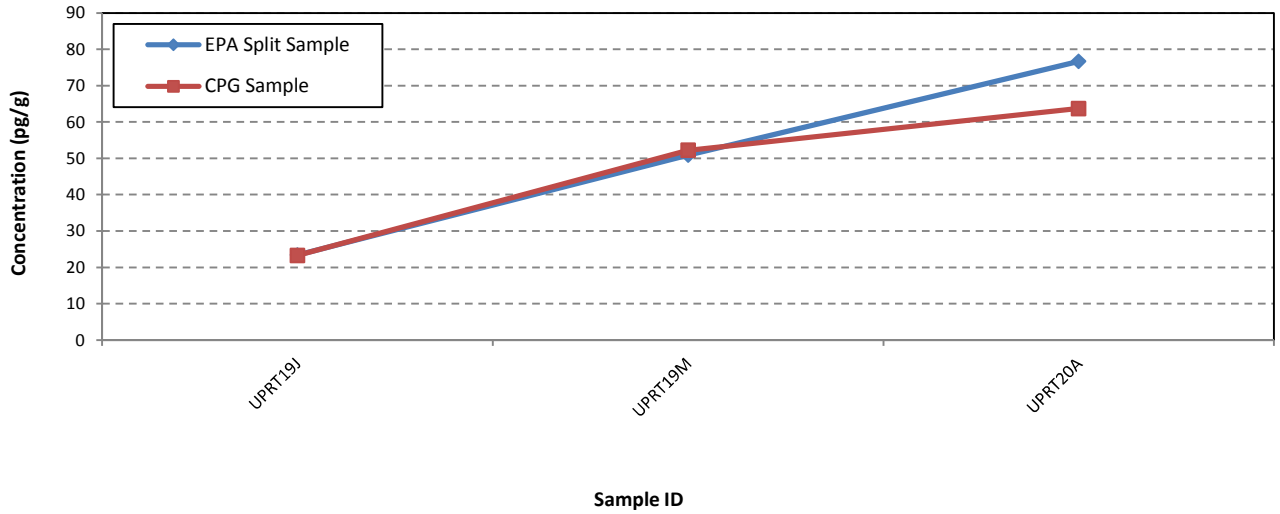



**Figure 24b: Bivariate Plot of 2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167) Concentrations**

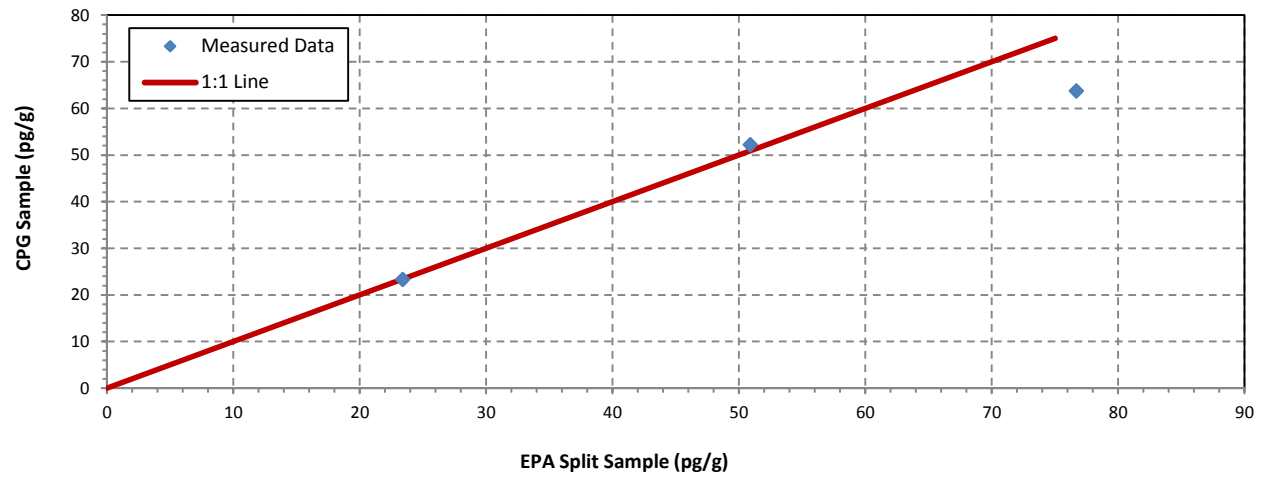
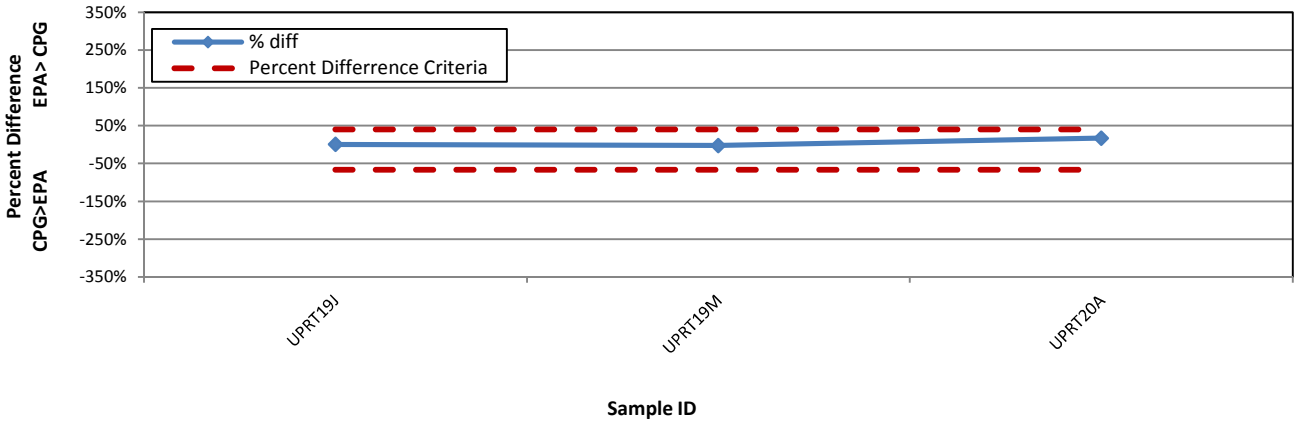



**Figure 24c: Line Plot of 2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167) Concentrations**

**Figure 24**

PCB = polychlorinated biphenyl

CDM Smith

No comparison possbile because none of the sample locations had detected concentrations on both USEPA and CPG samples

No comparison possbile because none of the sample locations had detected concentrations on both USEPA and CPG samples

No comparison possbile because none of the sample locations had detected concentrations on both USEPA and CPG samples

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**Statistical Plot of Sediment 3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169) Concentrations**

**Figure 25**

PCB = polychlorinated biphenyl

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**Figure 26a: Line Plot of 2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189) Concentrations**

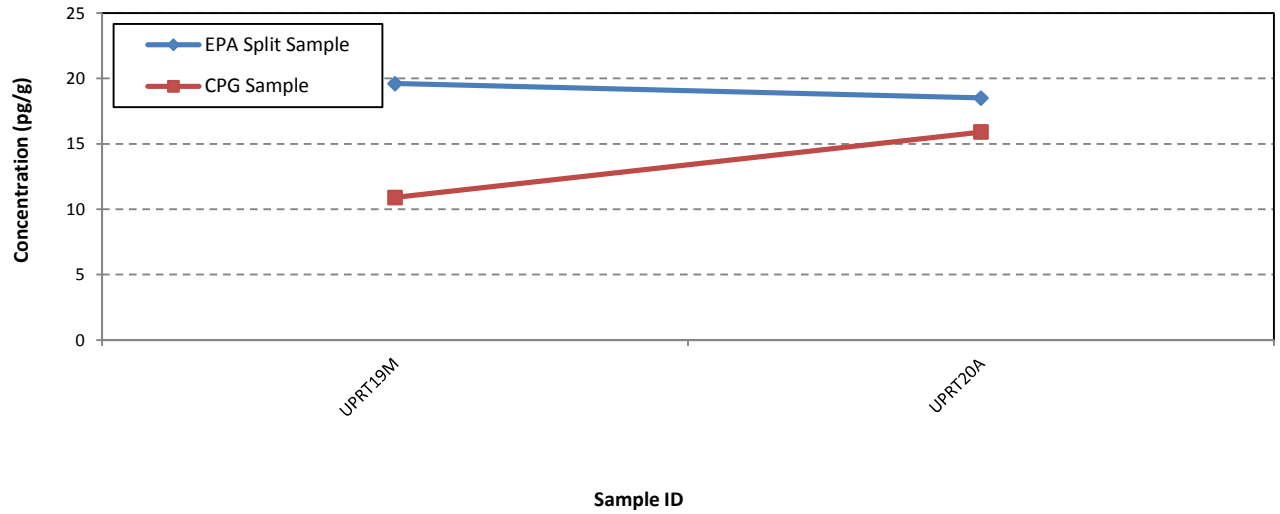



**Figure 26b: Bivariate Plot of 2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189) Concentrations**

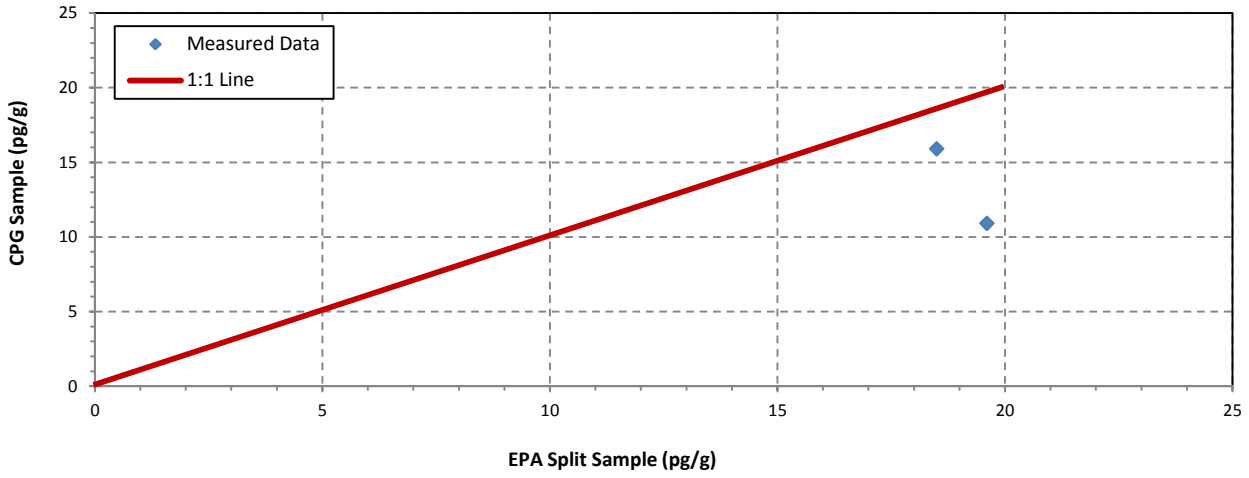
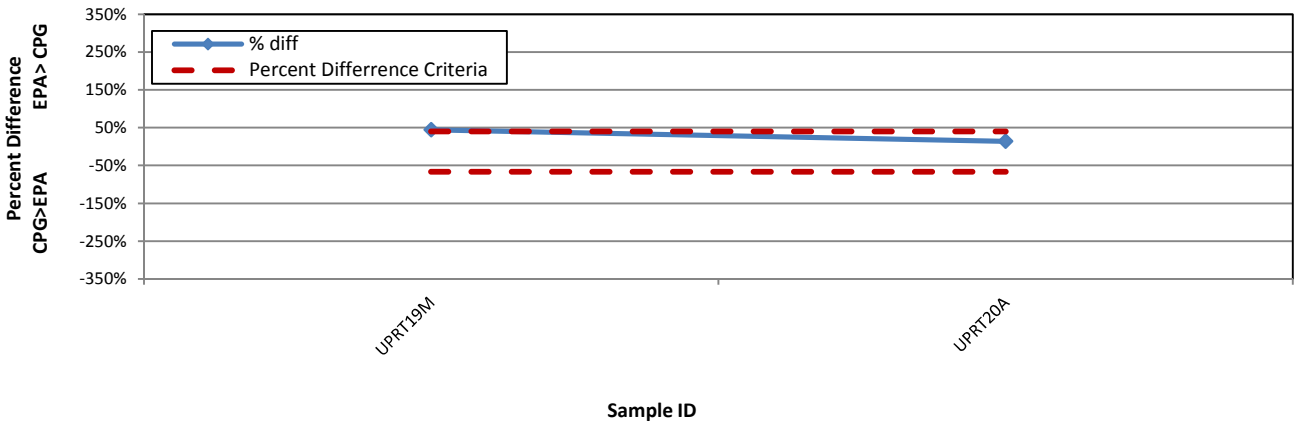



**Figure 26c: Line Plot of 2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment 2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189) Concentrations**

**Figure 26**

PCB = polychlorinated biphenyl

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**Figure 27a: Line Plot of Total PCB Concentrations**

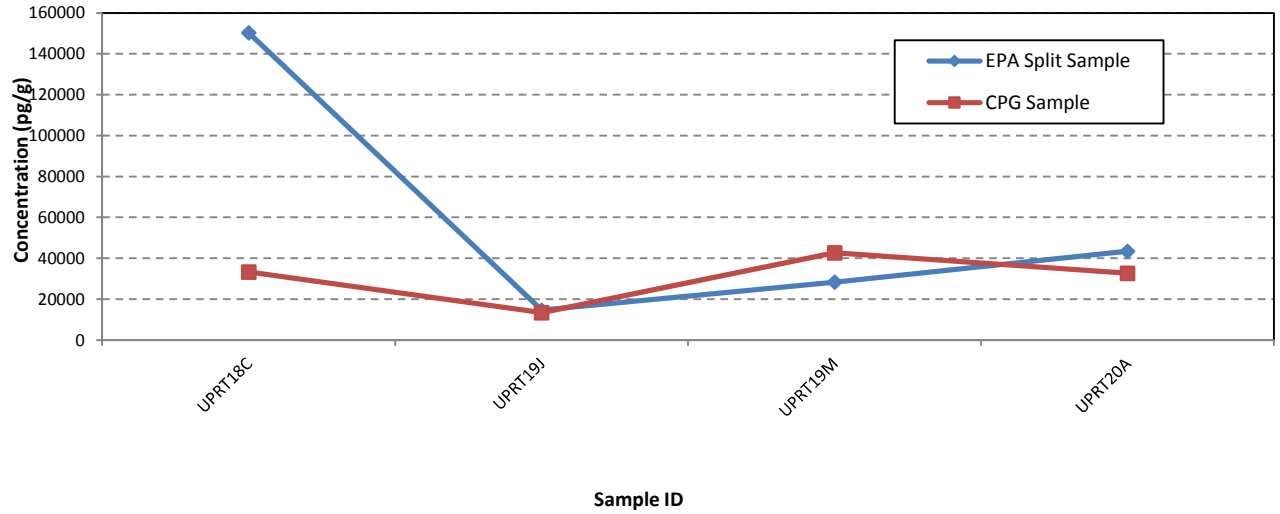



**Figure 27b: Bivariate Plot of Total PCB Concentrations**

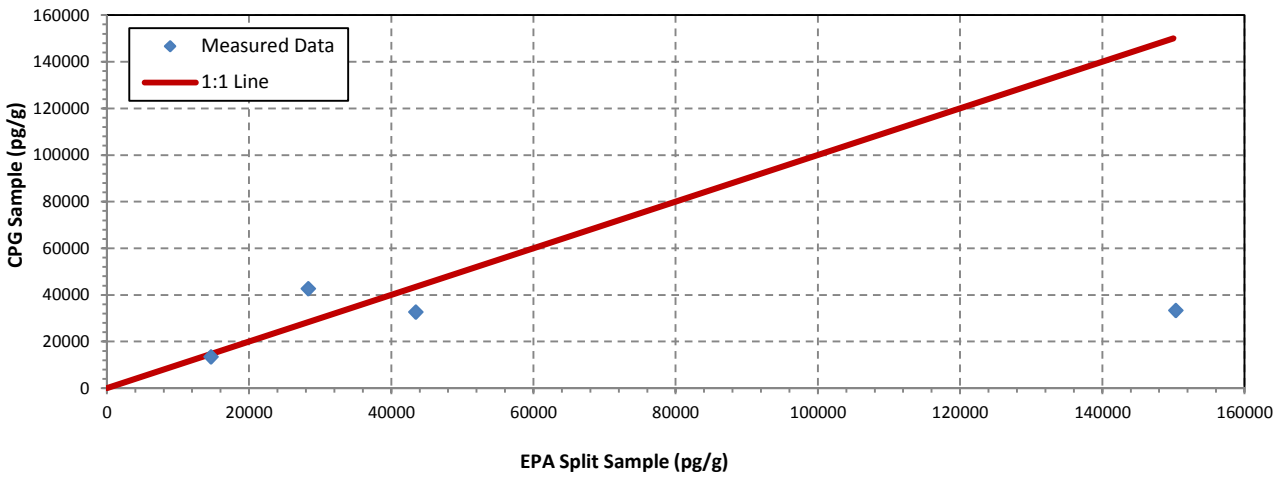
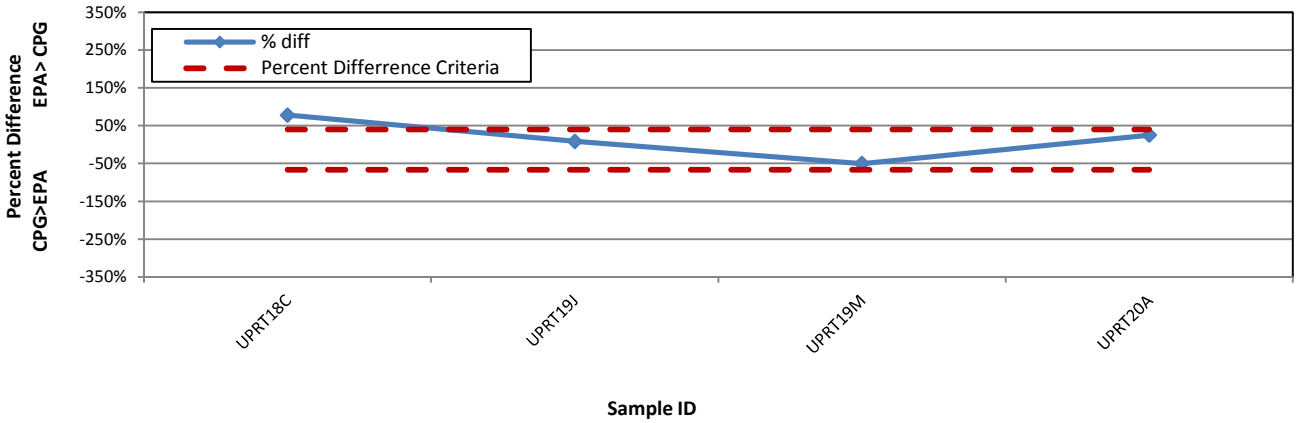



**Figure 27c: Line Plot of Total PCB Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Total PCB Concentrations**

**Figure 27**

PCB = polychlorinated biphenyl

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**Figure 28a: Line Plot of Anthracene Concentrations**

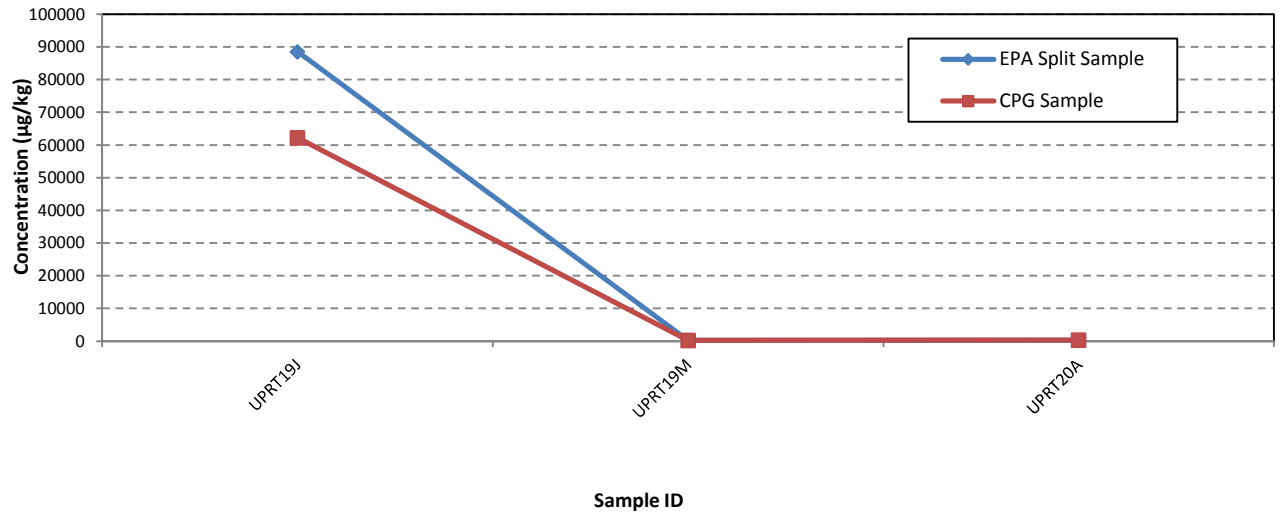



**Figure 28b: Bivariate Plot of Anthracene Concentrations**

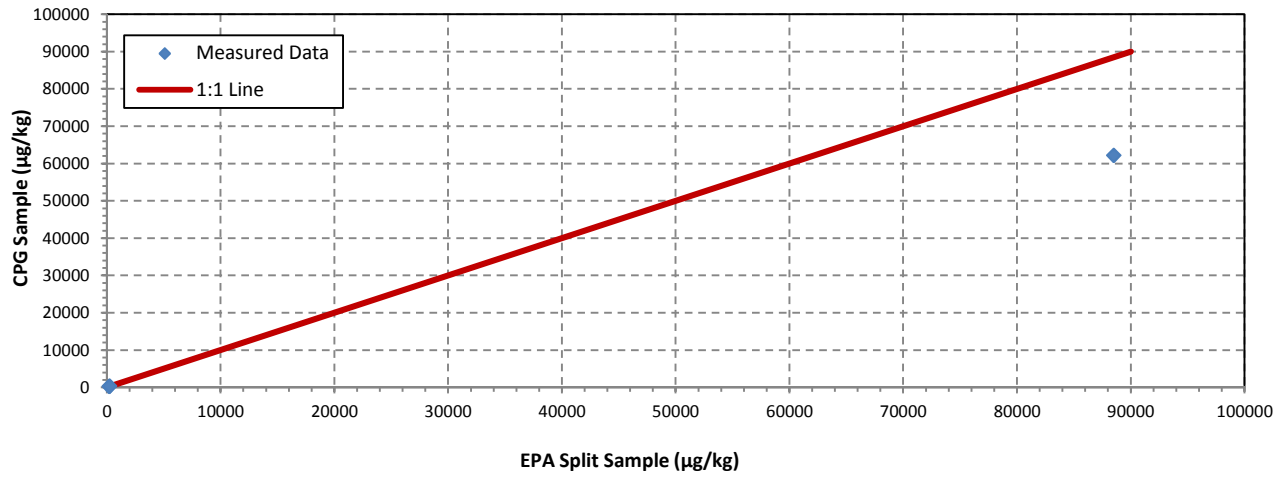
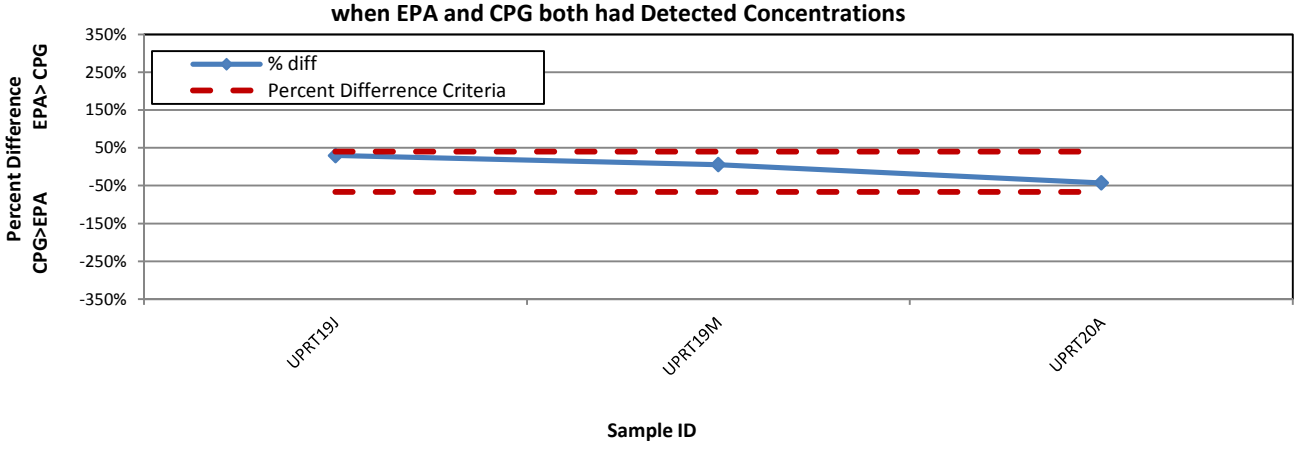



**Figure 28c: Line Plot of Anthracene Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Anthracene Concentrations**

**Figure 28**

CDM Smith

**Figure 29a: Line Plot of Benzo[a]anthracene Concentrations**

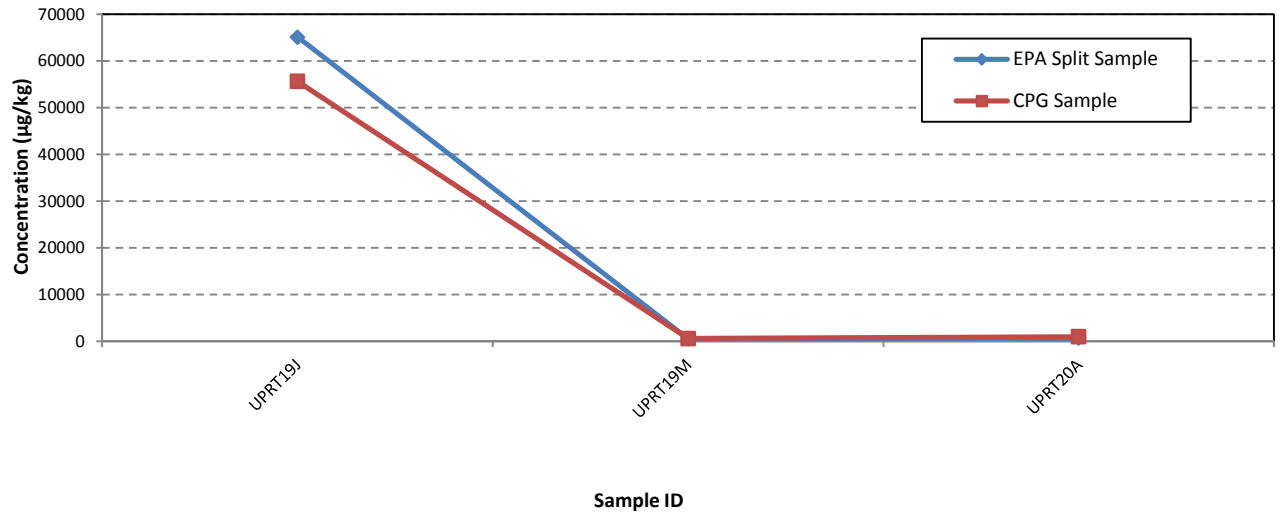



**Figure 29b: Bivariate Plot of Benz[a]anthracene Concentrations**

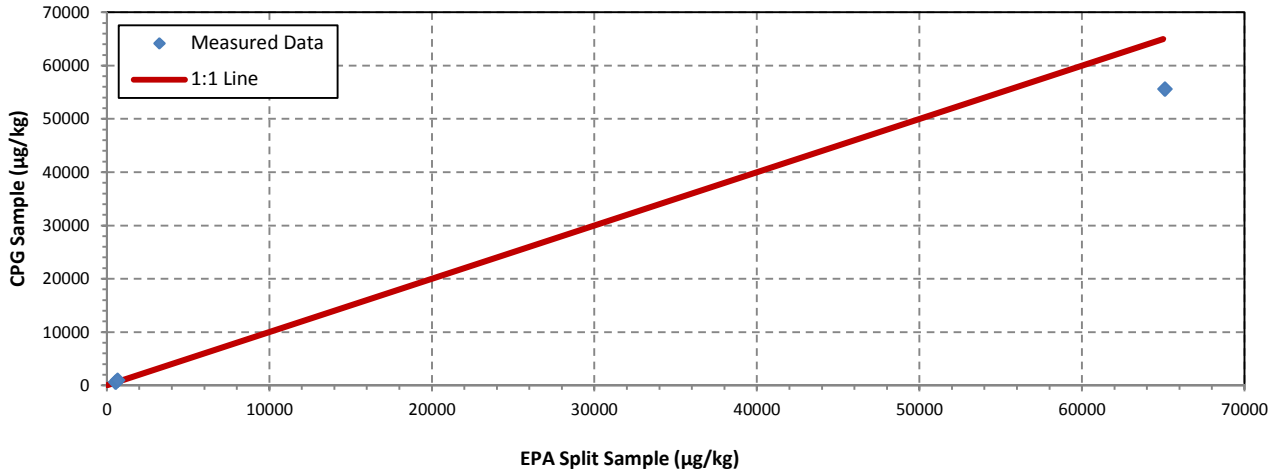
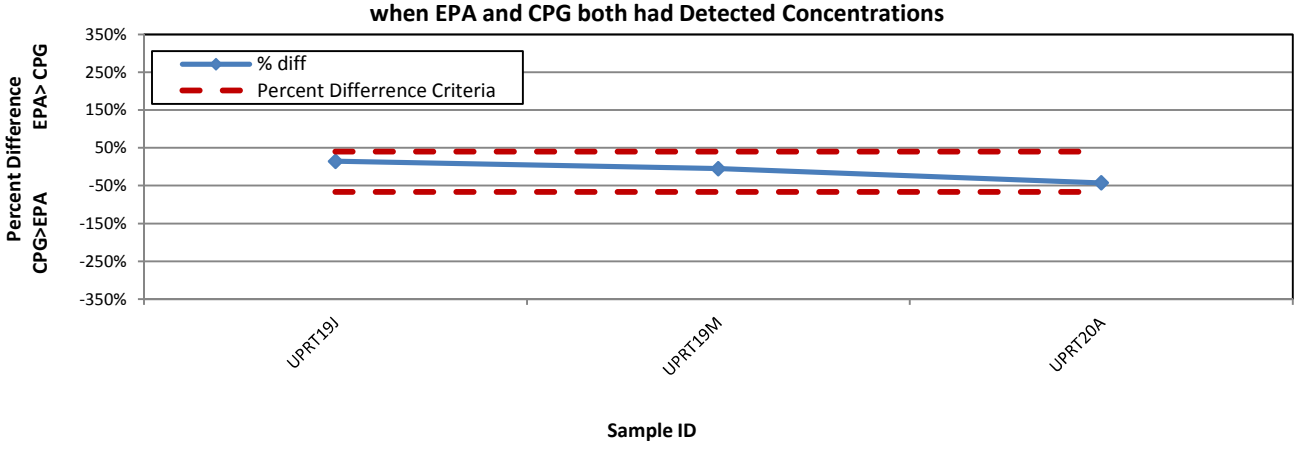



**Figure 29c: Line Plot of Benz[a]anthracene Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Benz[a]anthracene Concentrations**

**Figure 29**

CDM Smith

**Figure 30a: Line Plot of Benzo[a]pyrene Concentrations**

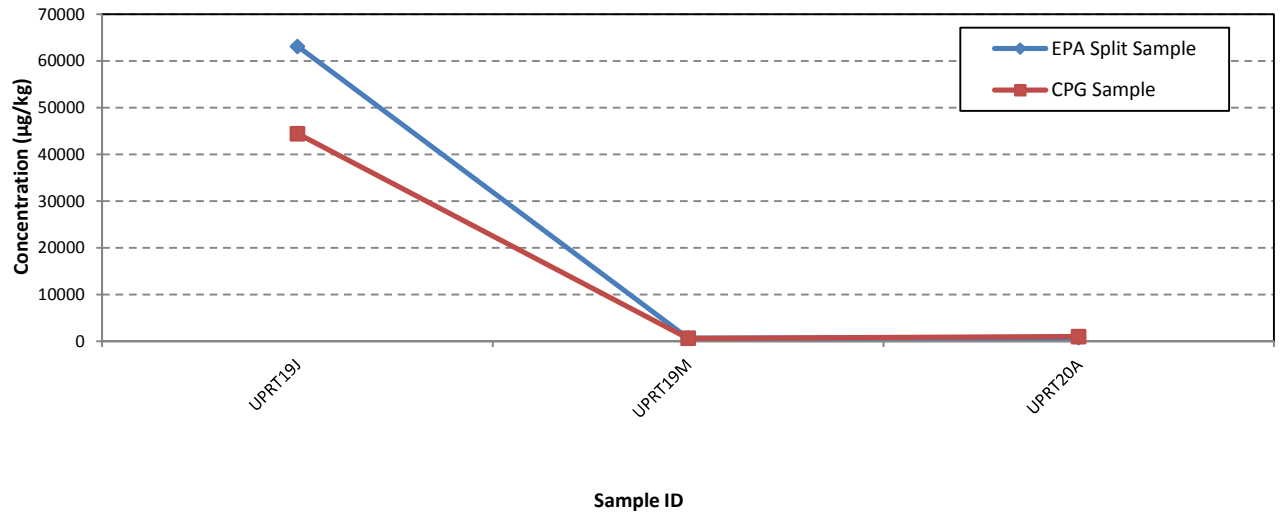



**Figure 30b: Bivariate Plot of Benzo[a]pyrene Concentrations**

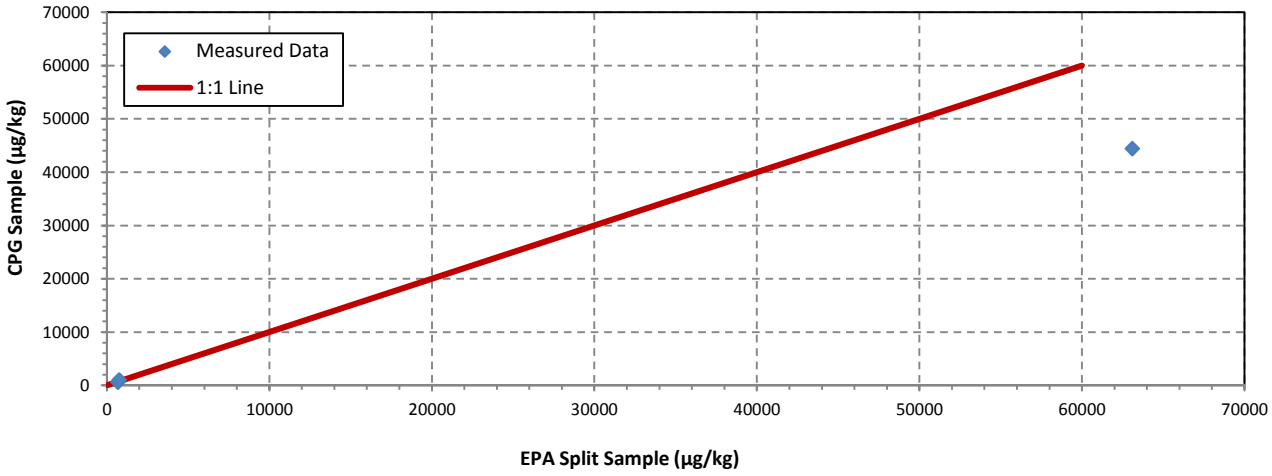
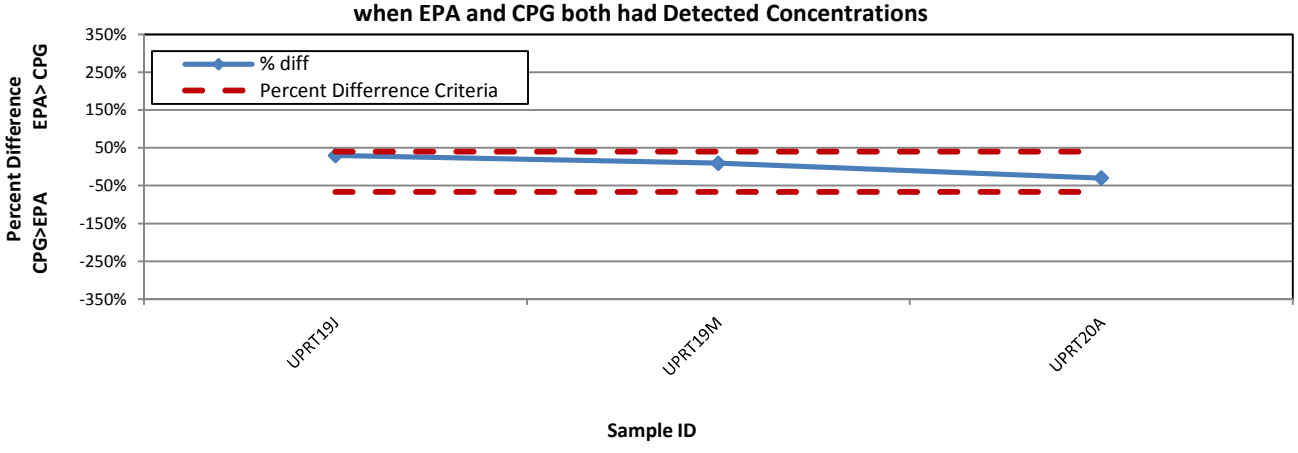



**Figure 30c: Line Plot of Benzo[a]pyrene Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment Benzo[a]pyrene Concentrations** | **Figure 30** |

CDM Smith

**Figure 31a: Line Plot of Chrysene Concentrations**

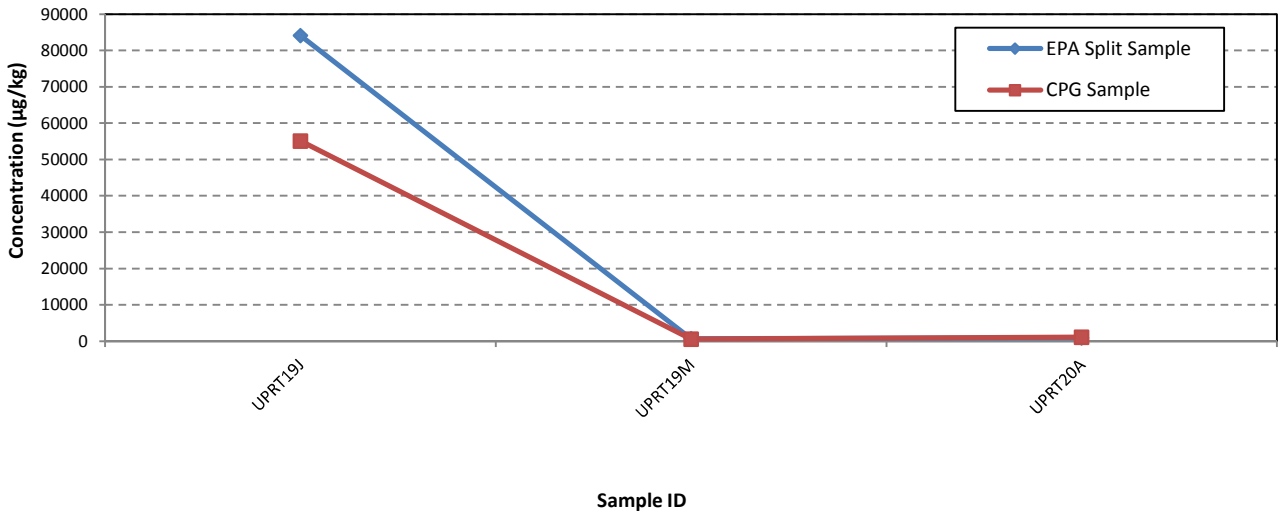



**Figure 31b: Bivariate Plot of Chrysene Concentrations**

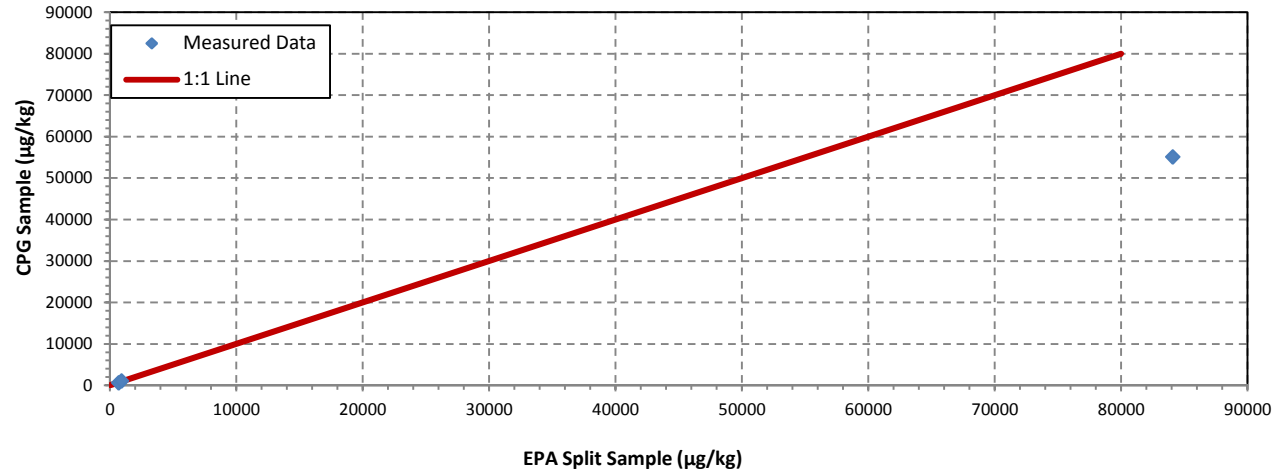
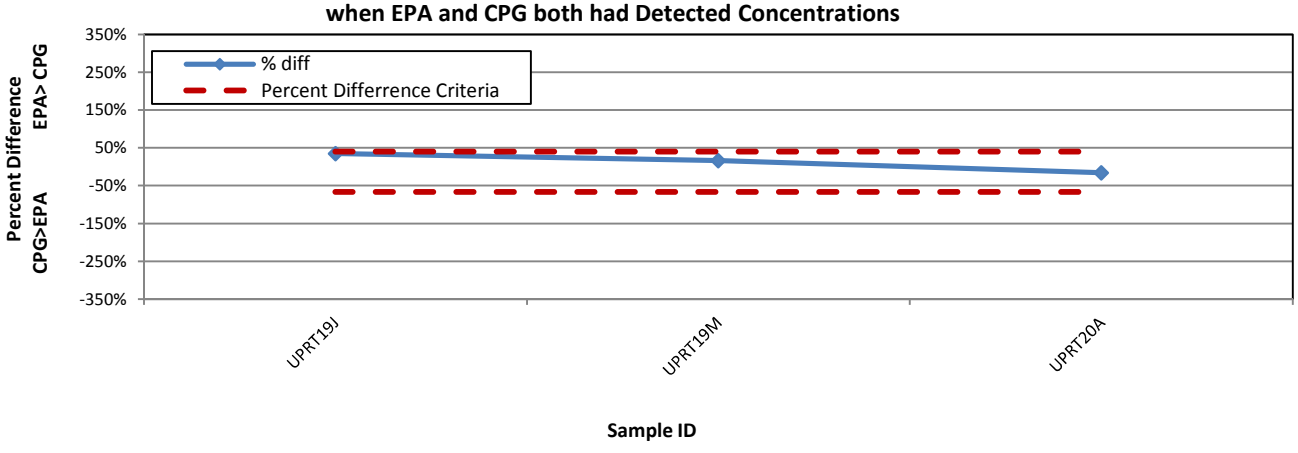



**Figure 31c: Line Plot of Chrysene Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Chrysene Concentrations**

**Figure 31**

CDM Smith

**Figure 32a: Line Plot of Fluoranthene Concentrations**

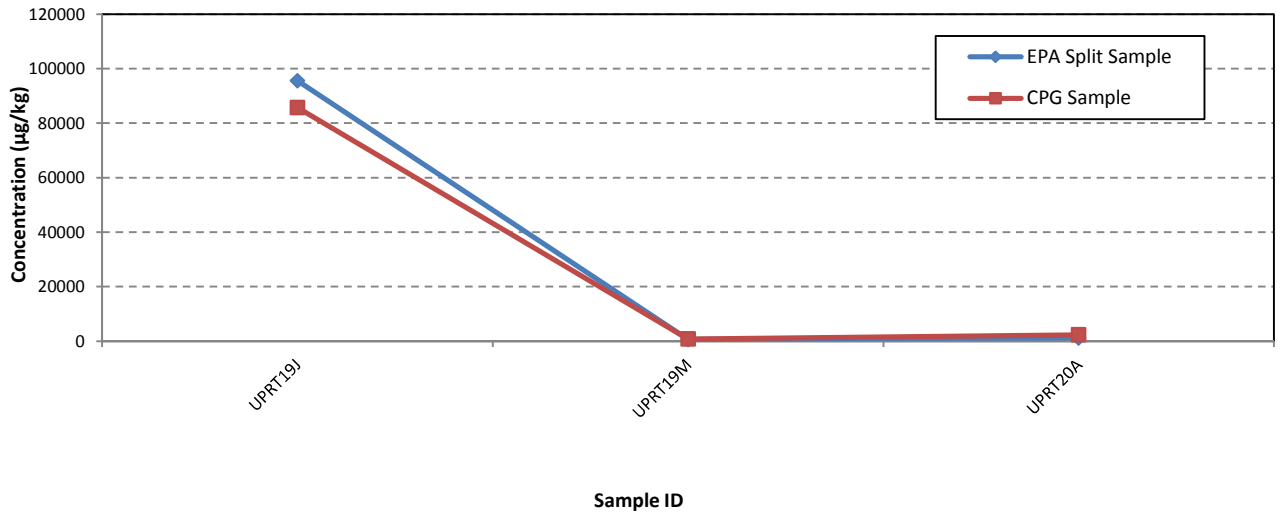



**Figure 32b: Bivariate Plot of Fluoranthene Concentrations**

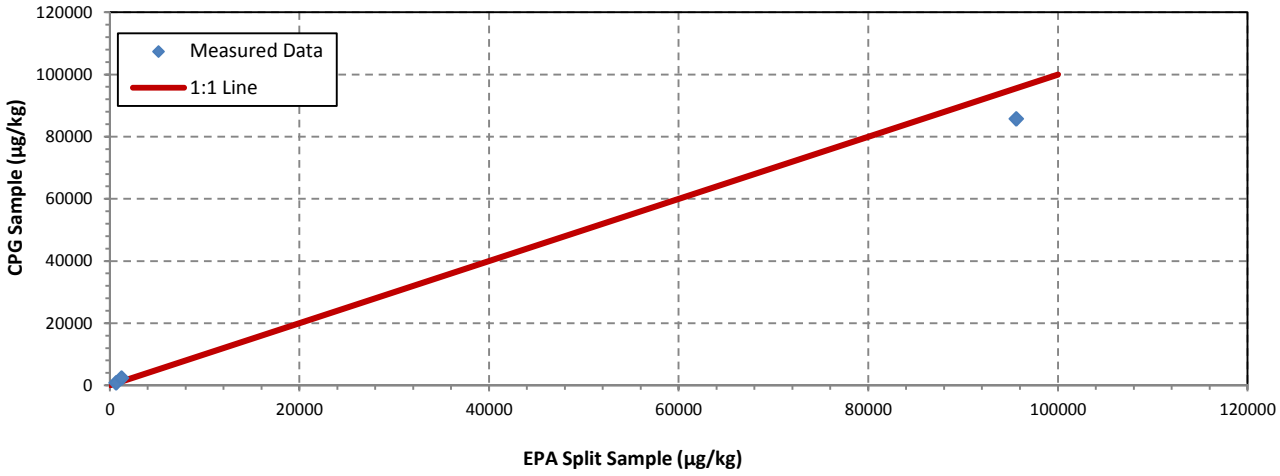
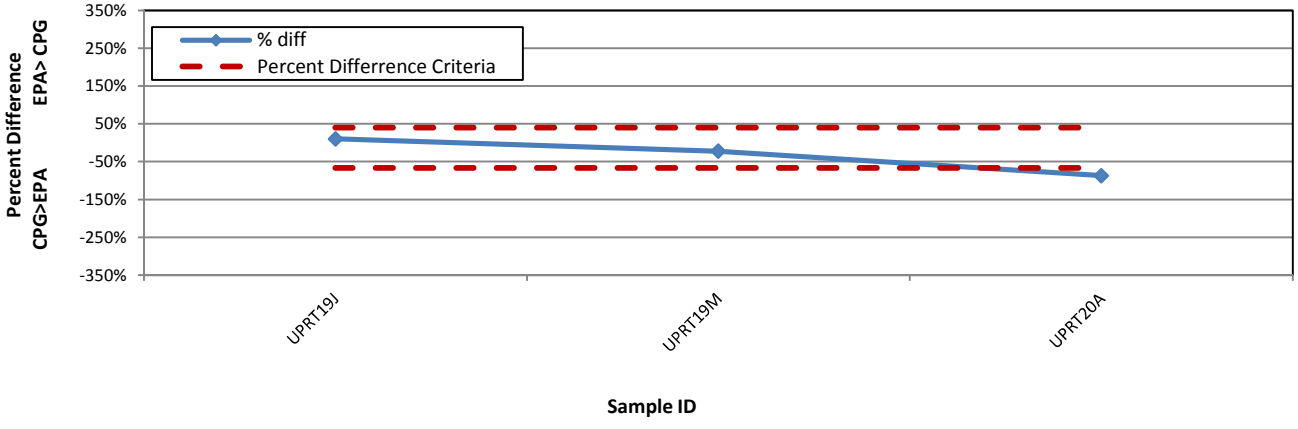



**Figure 32c: Line Plot of Fluoranthene Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Fluoranthene Concentrations**

**Figure 32**

CDM Smith

**Figure 33a: Line Plot of Indeno[1,2,3-cd]pyrene Concentrations**

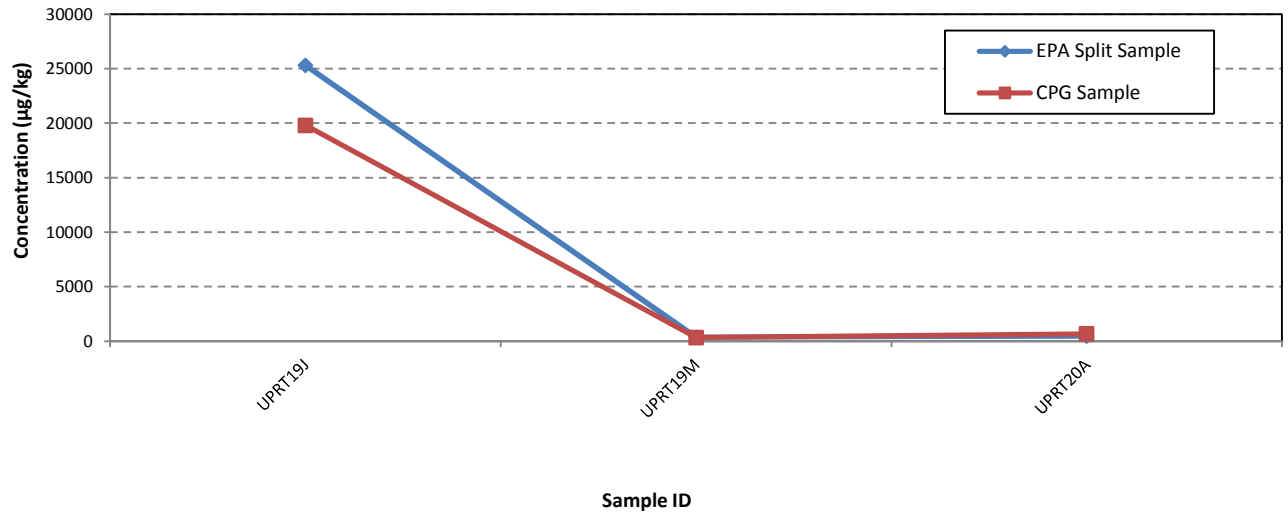



**Figure 33b: Bivariate Plot of Indeno[1,2,3-cd]pyrene Concentrations**

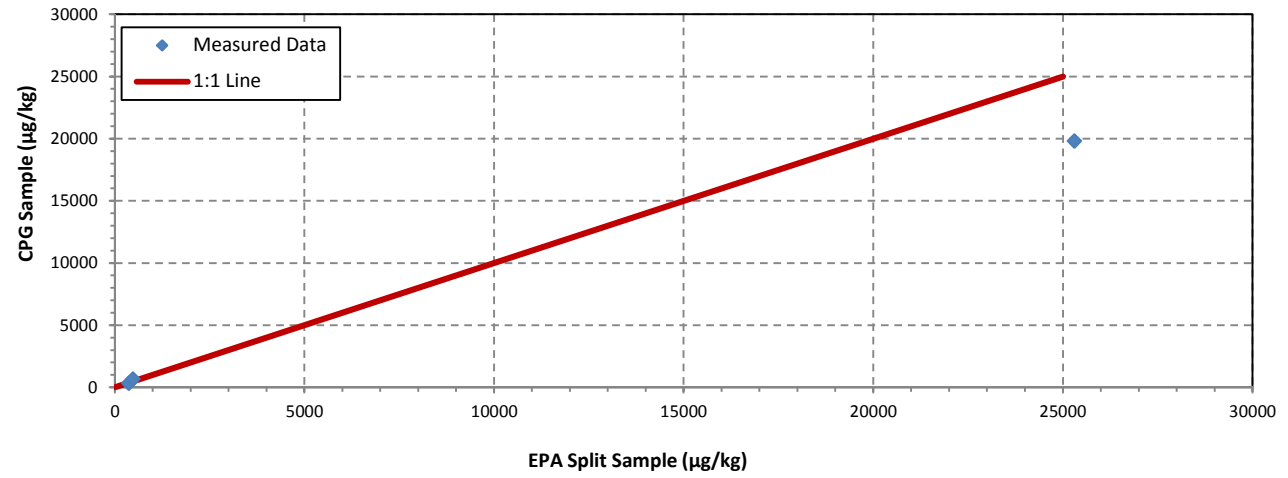
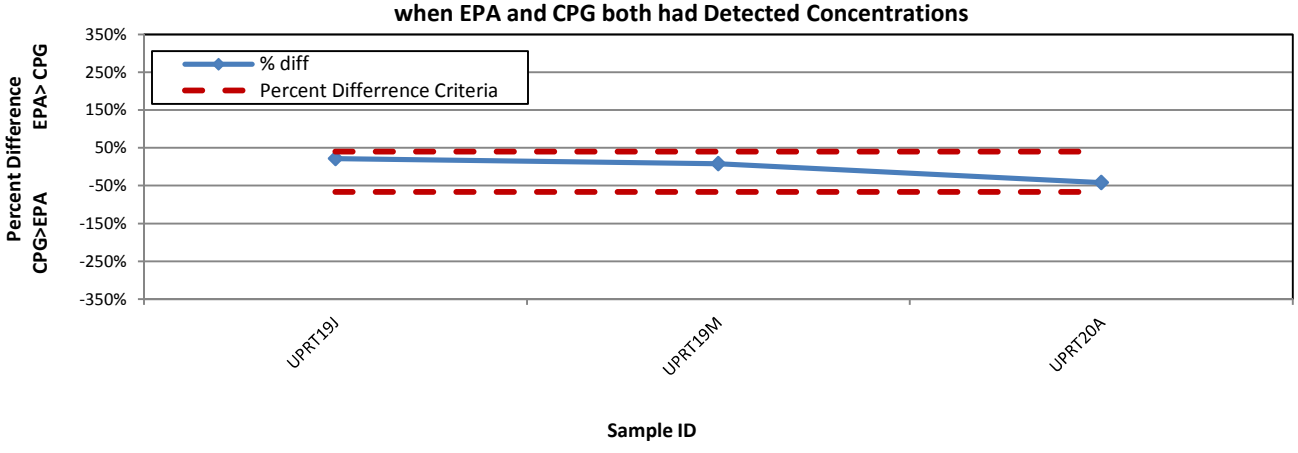



**Figure 33c: Line Plot of Indeno[1,2,3-cd]pyrene Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Indeno[1,2,3-cd]pyrene Concentrations**

**Figure 33**

CDM Smith

**Figure 34a: Line Plot of Naphthalene Concentrations**

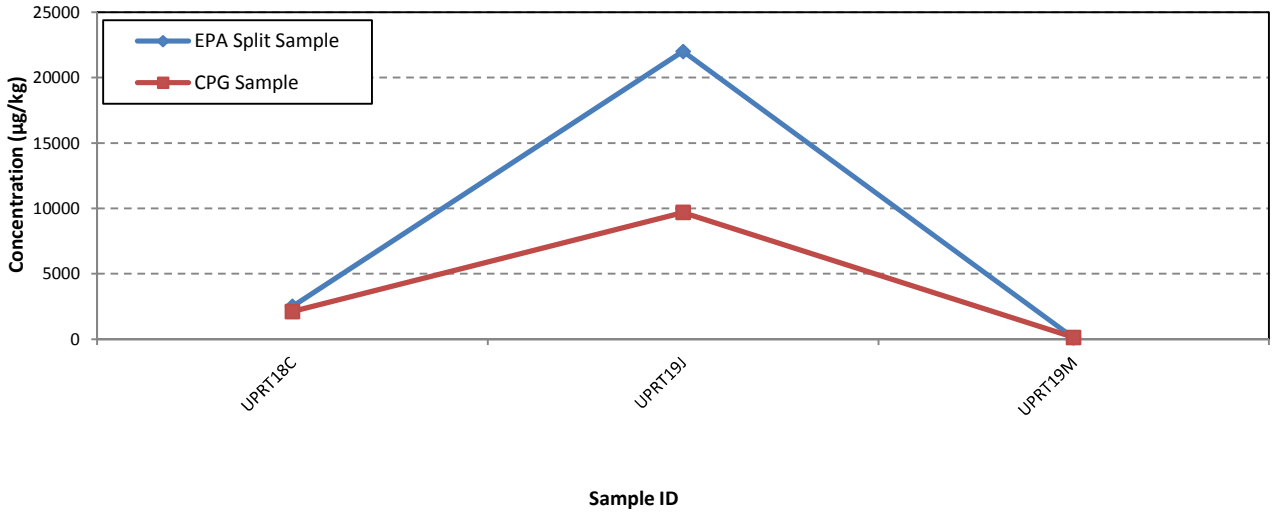



**Figure 34b: Bivariate Plot of Naphthalene Concentrations**

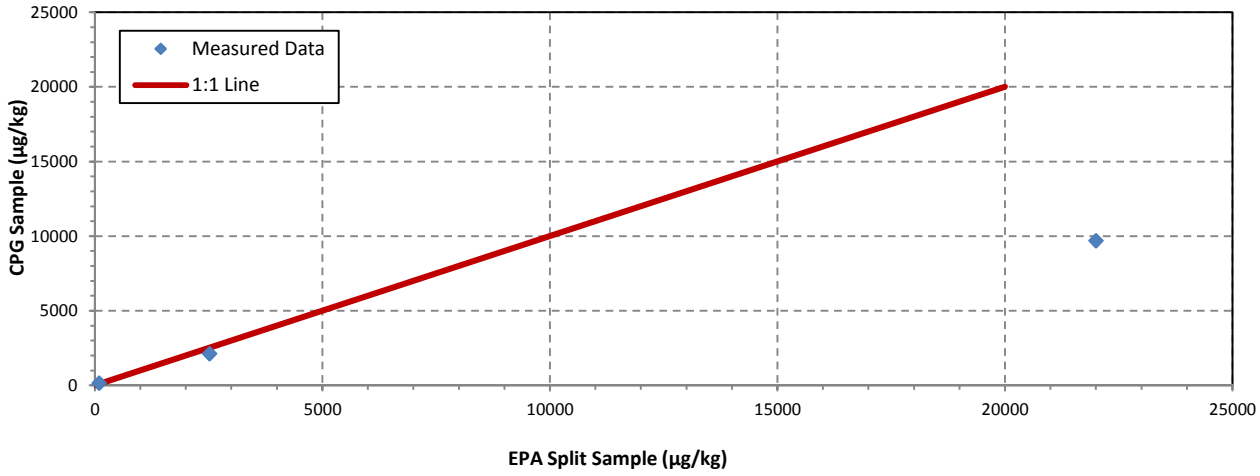
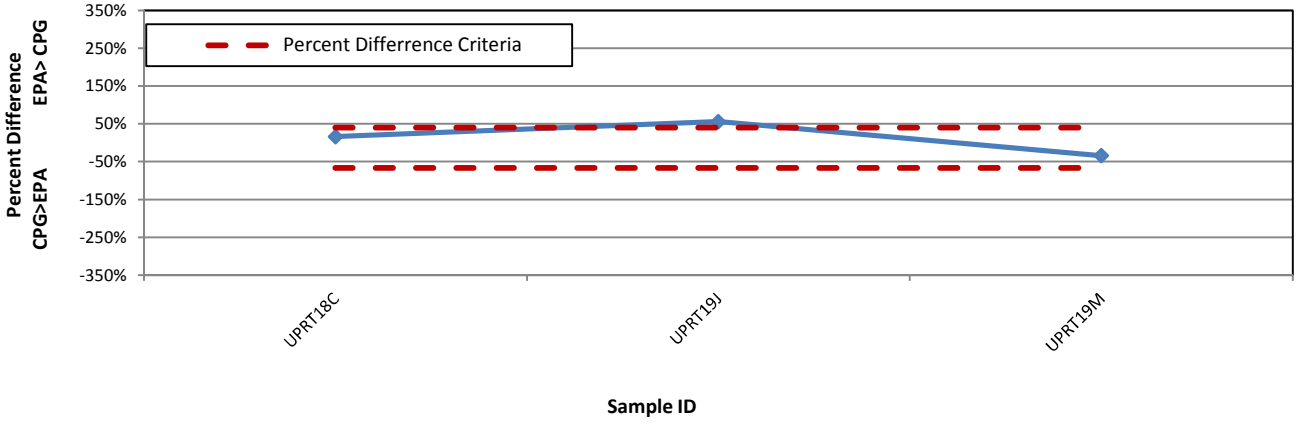



**Figure 34c: Line Plot of Naphthalene Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Naphthalene Concentrations**

**Figure 34**

CDM Smith

**Figure 35a: Line Plot of Phenanthrene Concentrations**

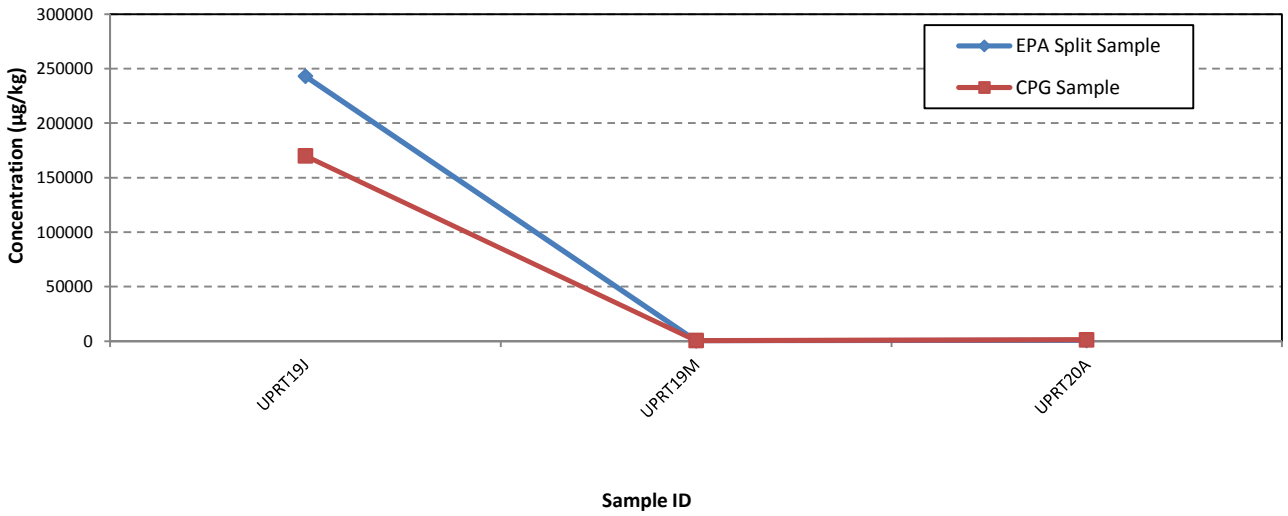



**Figure 35b: Bivariate Plot of Phenanthrene Concentrations**

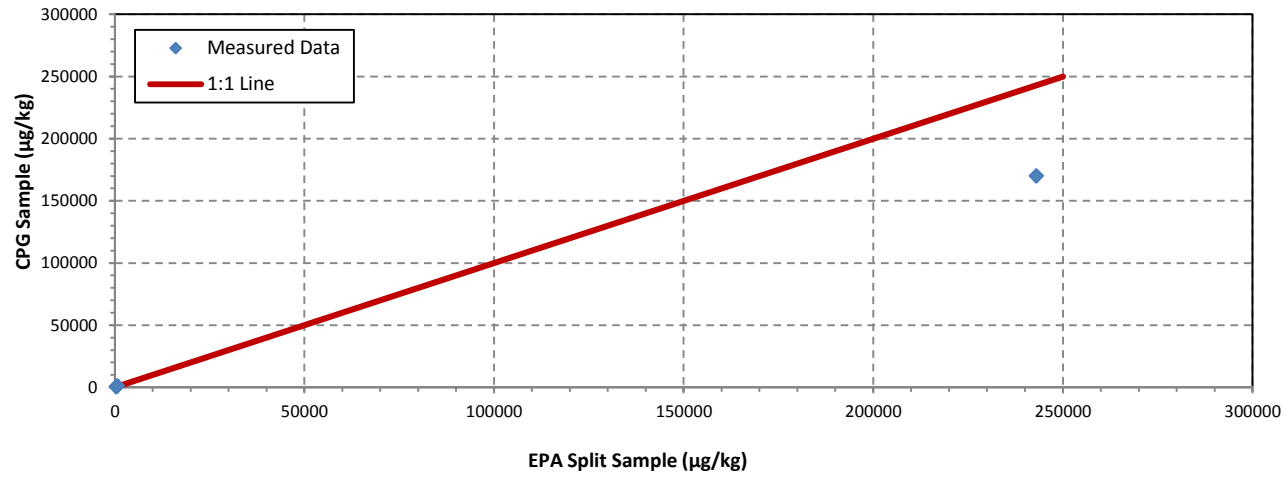
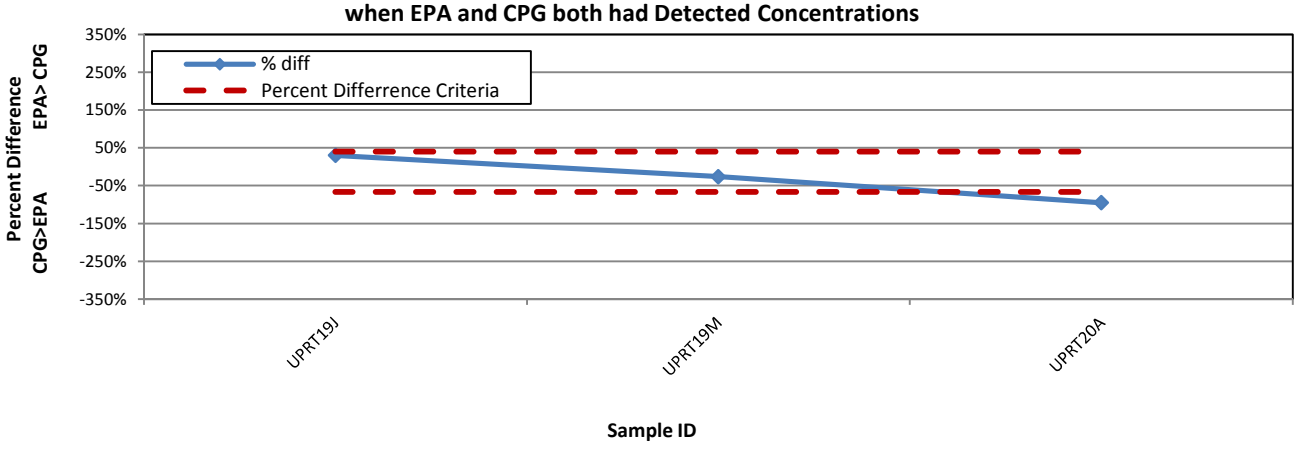



**Figure 35c: Line Plot of Phenanthrene Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Phenanthrene Concentrations**

**Figure 35**

CDM Smith

**Figure 36a: Line Plot of Pyrene Concentrations**

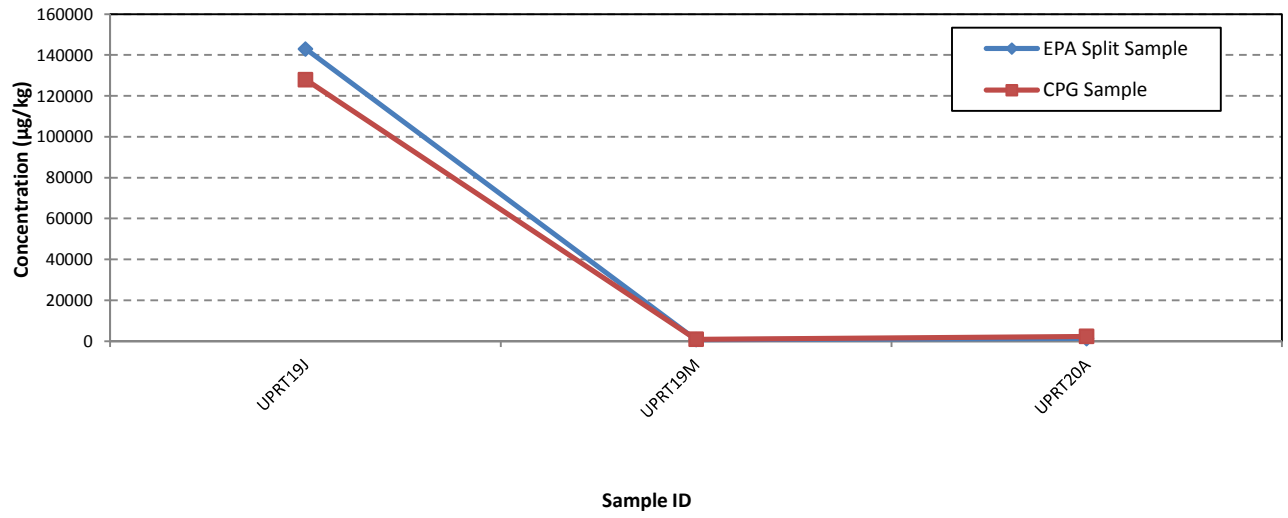



**Figure 36b: Bivariate Plot of Pyrene Concentrations**

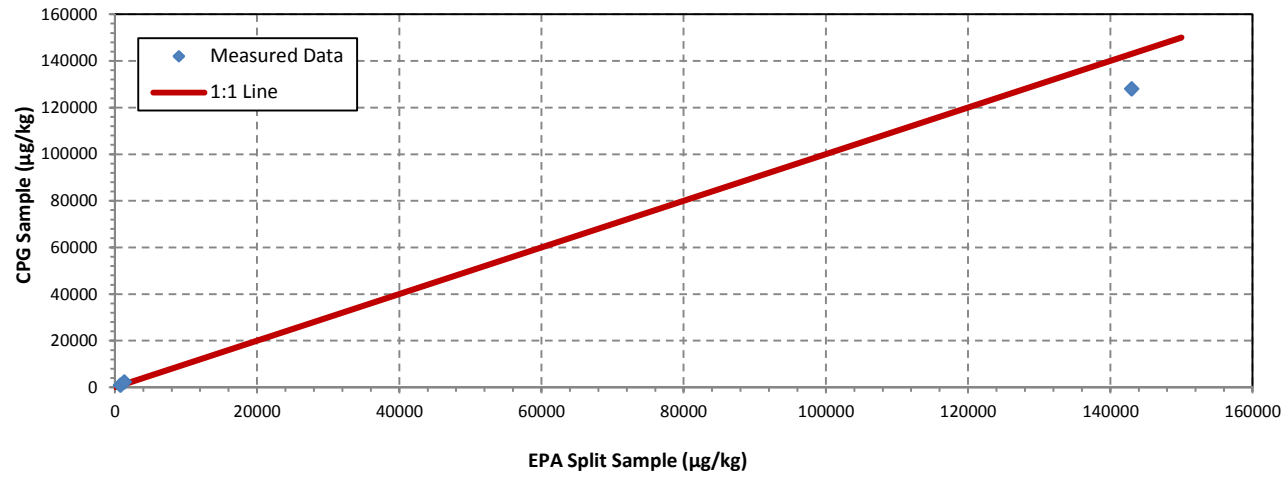
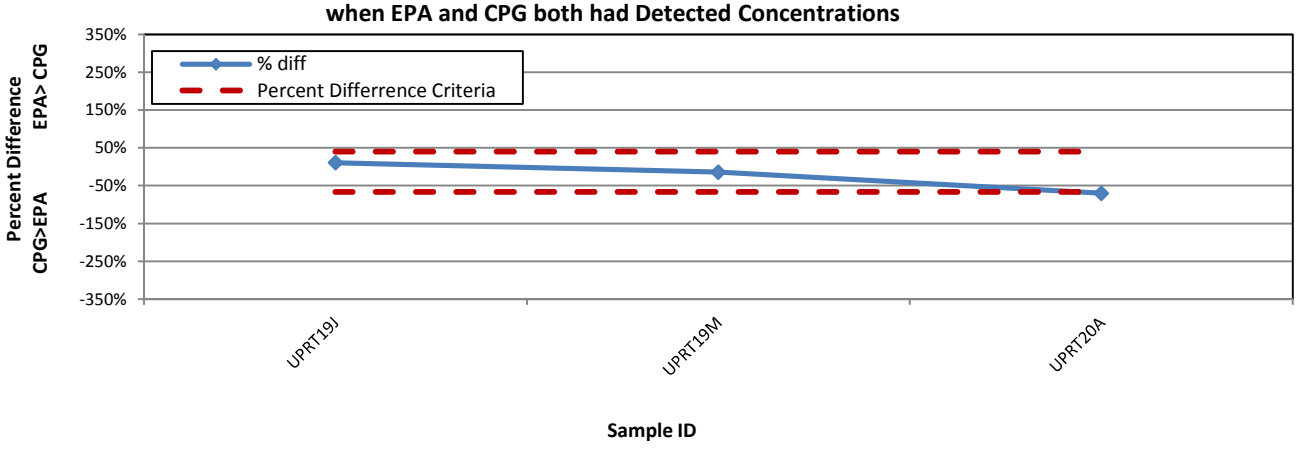



**Figure 36c: Line Plot of Pyrene Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Pyrene Concentrations**

**Figure 36**

CDM Smith

**Figure 37a: Line Plot of Total Organic Carbon Concentrations**

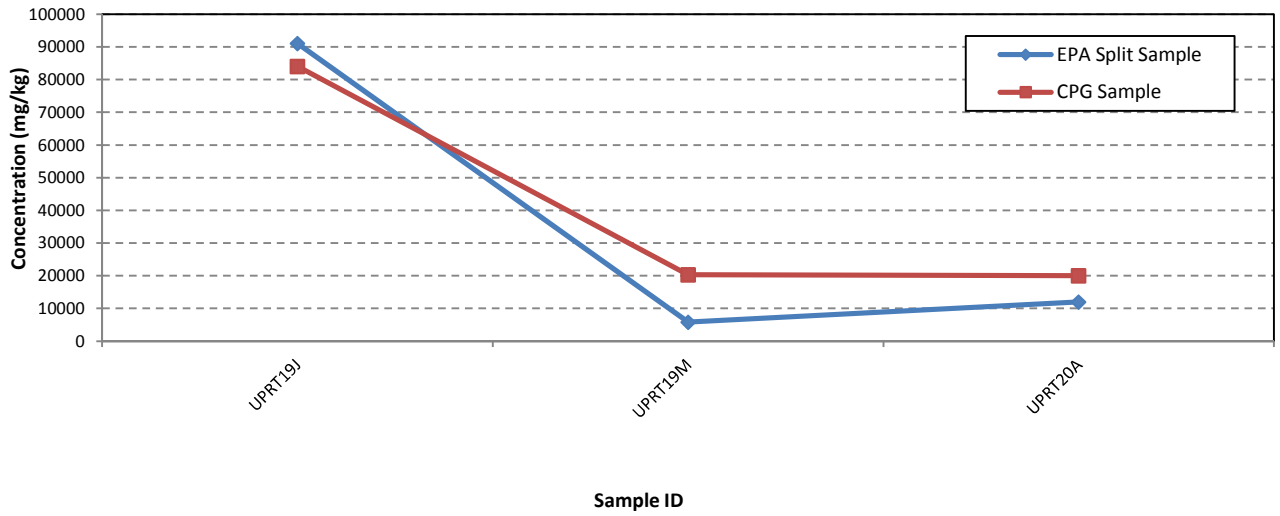



**Figure 37b: Bivariate Plot of Total Organic Carbon Concentrations**

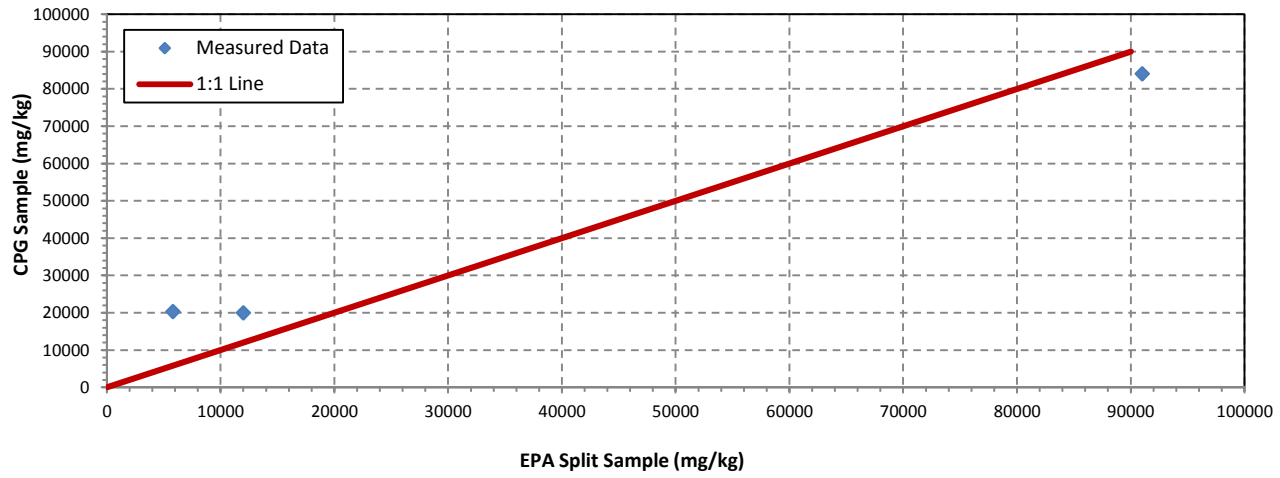
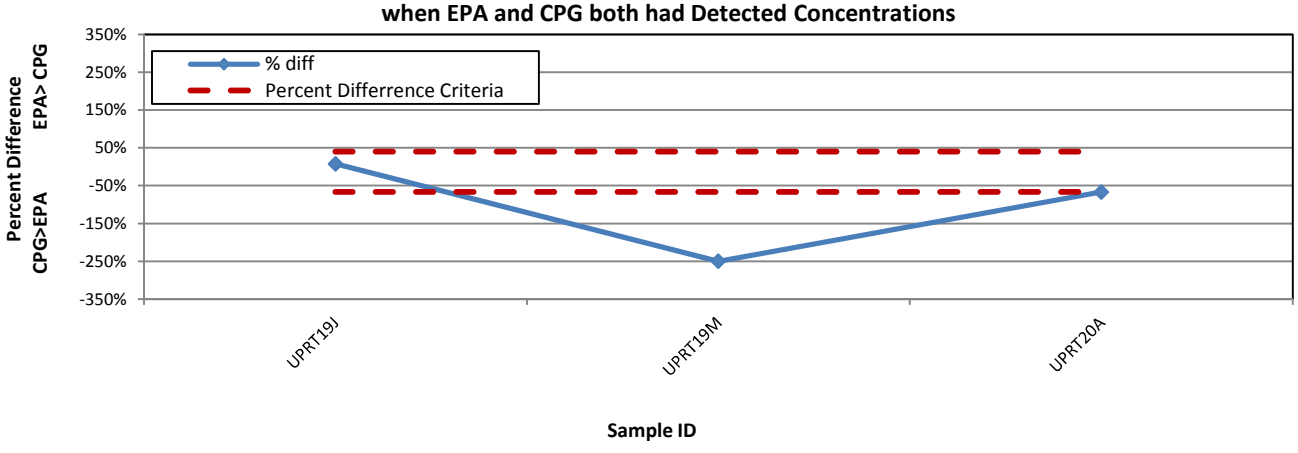



**Figure 37c: Line Plot of Total Organic Carbon Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Total Organic Carbon Concentrations**

**Figure 37**

CDM Smith

**Figure 38a: Line Plot of Arsenic Concentrations**

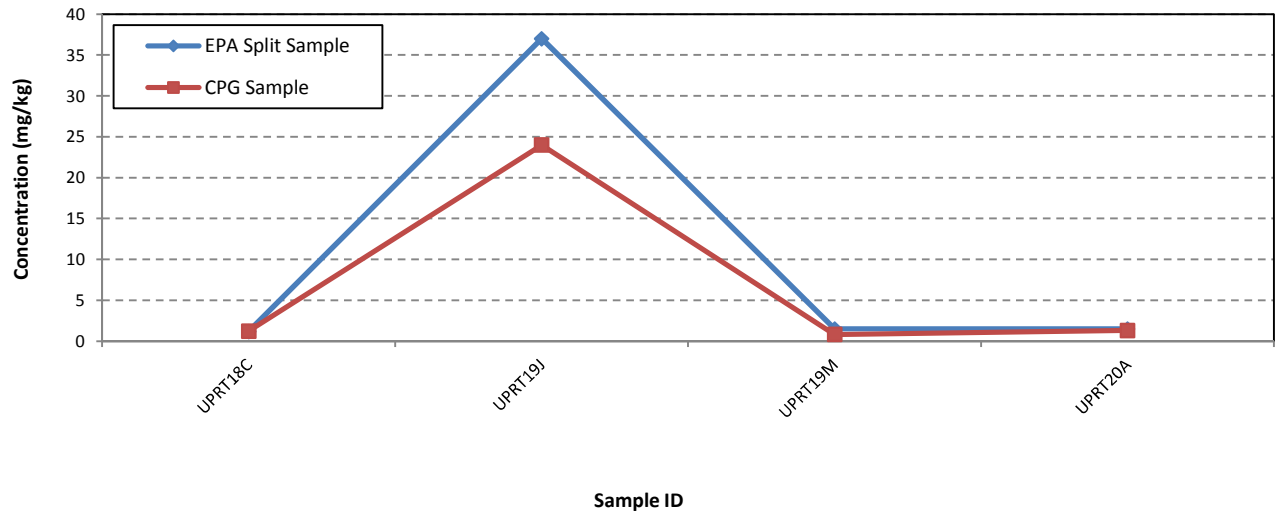



**Figure 38b: Bivariate Plot of Arsenic Concentrations**

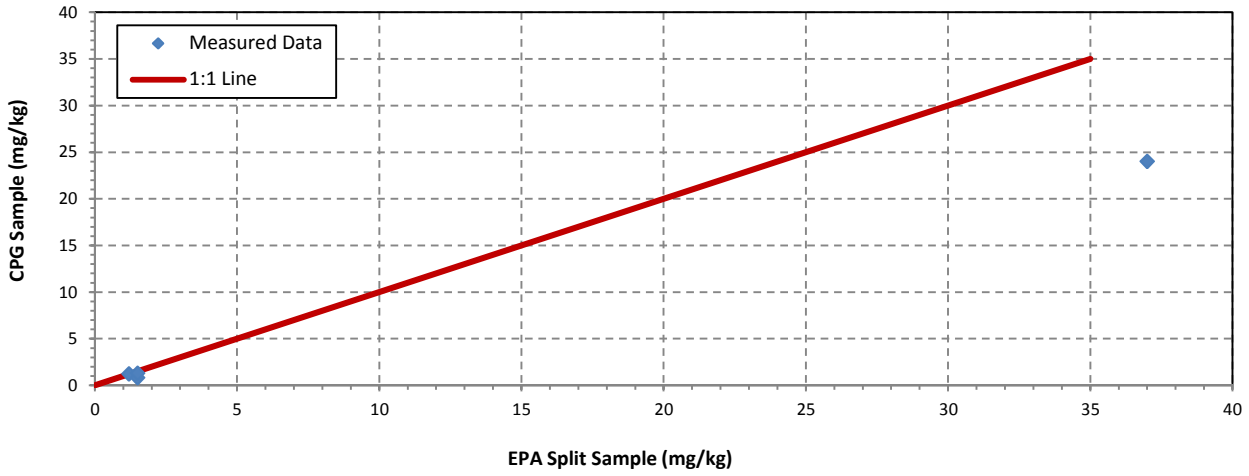
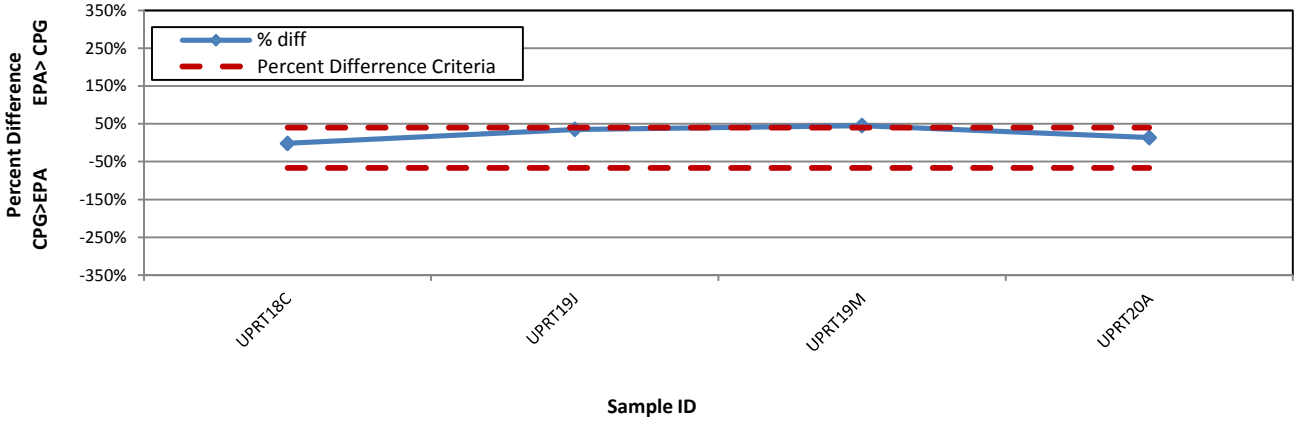



**Figure 38c: Line Plot of Arsenic Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment Arsenic Concentrations** | **Figure 38** |

CDM Smith

**Figure 39a: Line Plot of Barium Concentrations**

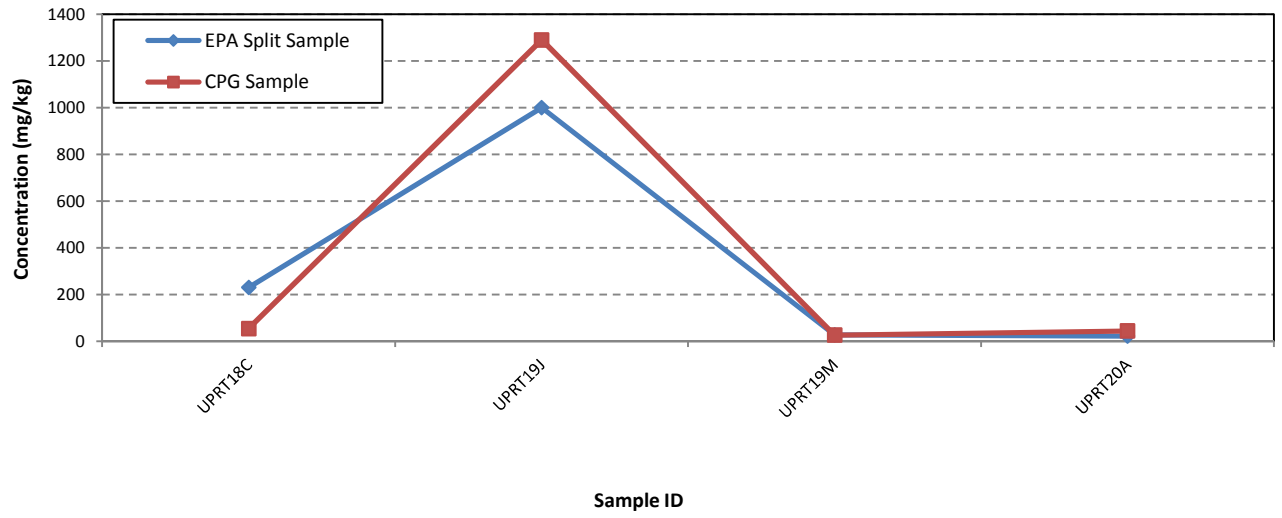



**Figure 39b: Bivariate Plot of Barium Concentrations**

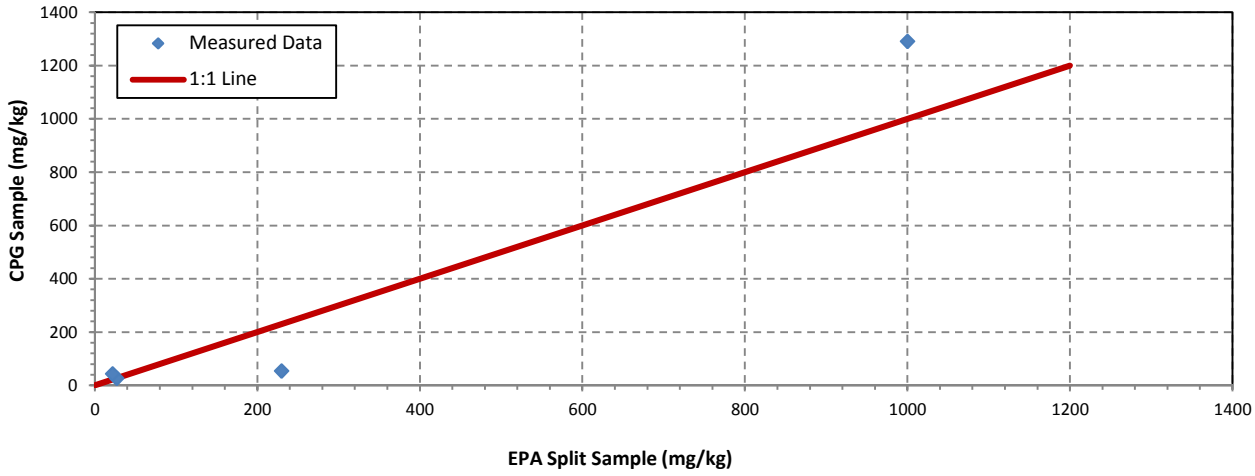
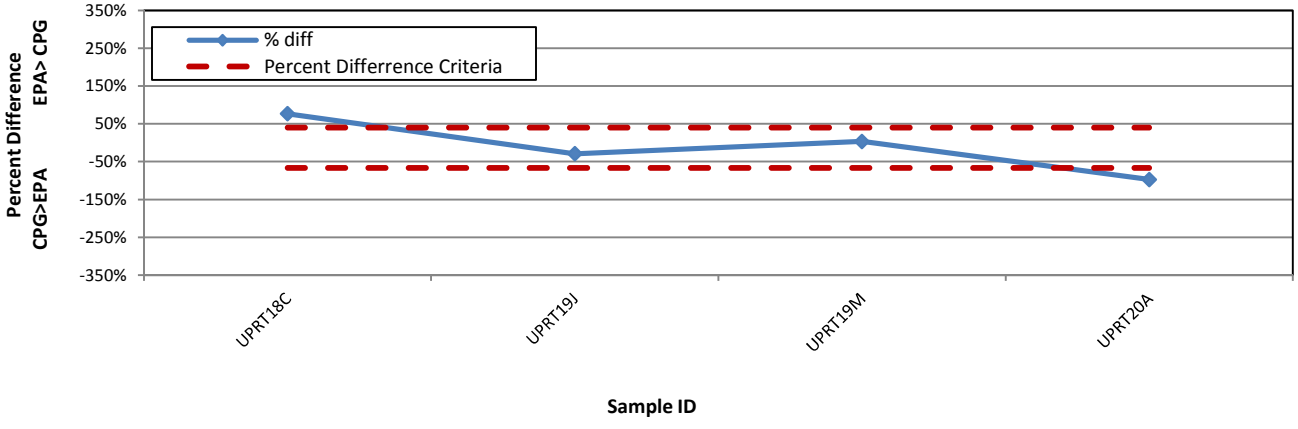



**Figure 39c: Line Plot of Barium Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment Barium Concentrations** | **Figure 39** |

CDM Smith

**Figure 40a: Line Plot of Cadmium Concentrations**

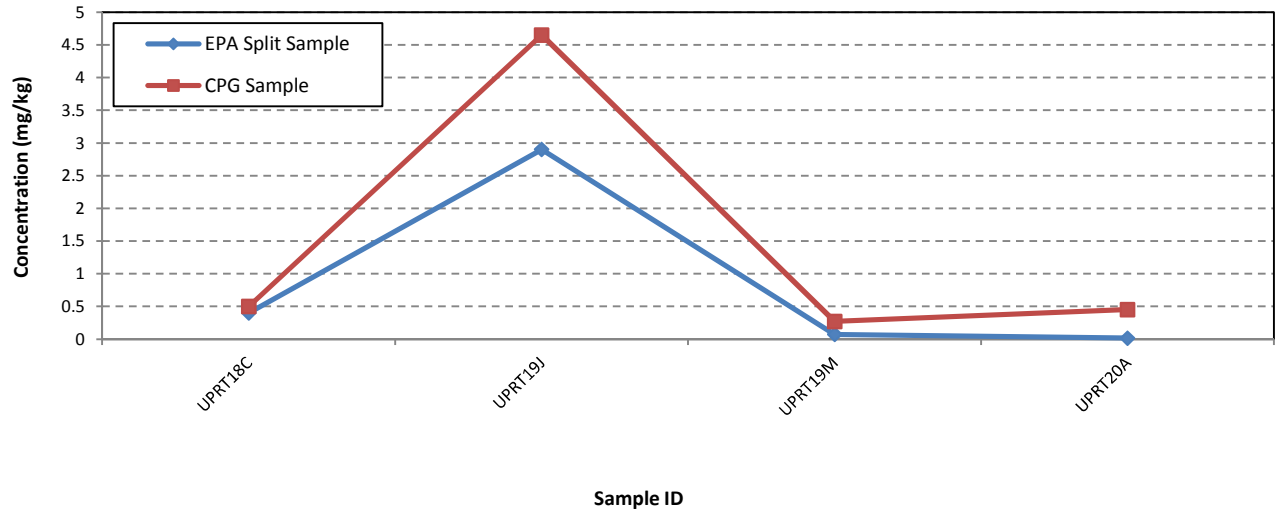



**Figure 40b: Bivariate Plot of Cadmium Concentrations**

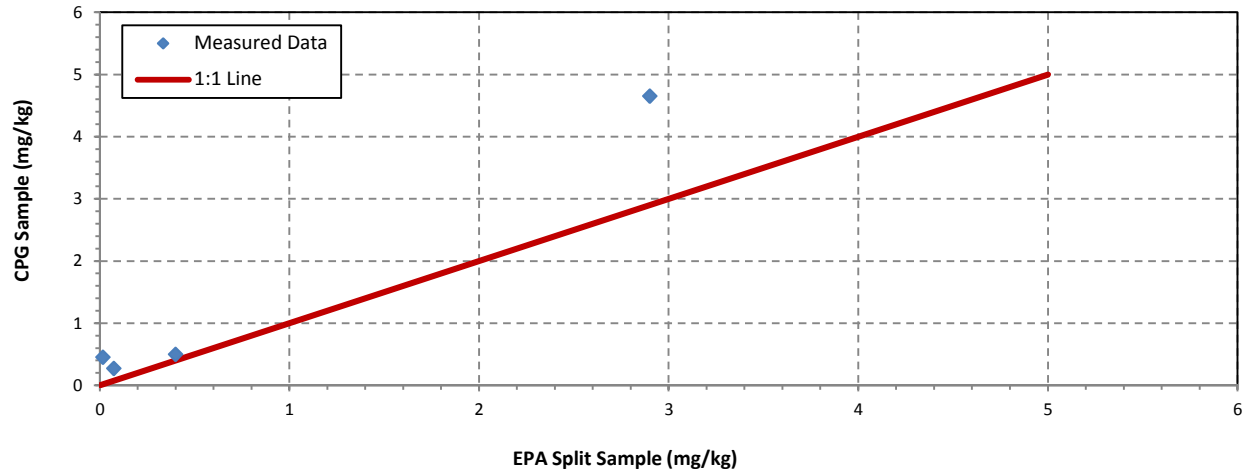
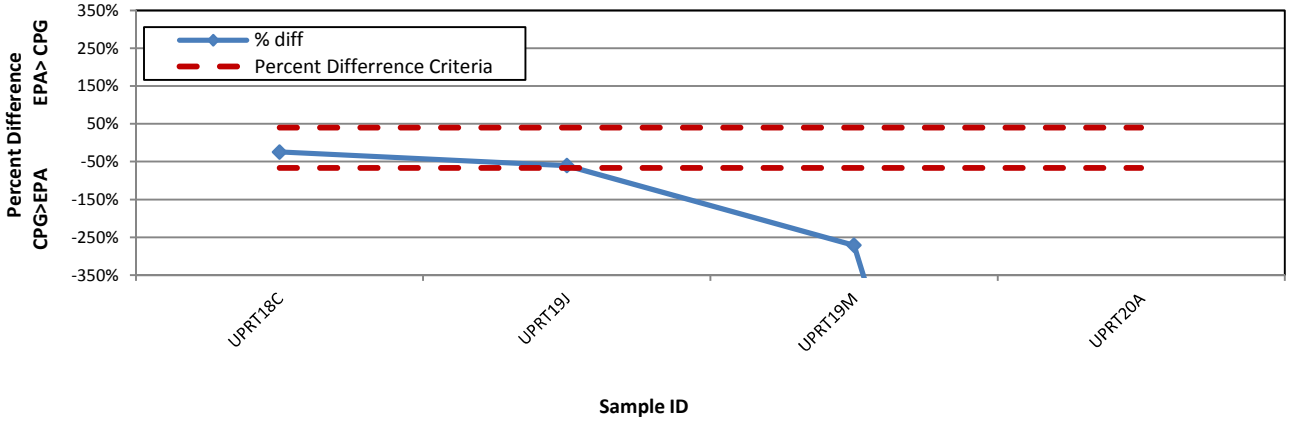



**Figure 40c: Line Plot of Cadmium Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment Cadmium Concentrations** | **Figure 40** |

CDM Smith

**Figure 41a: Line Plot of Chromium Concentrations**

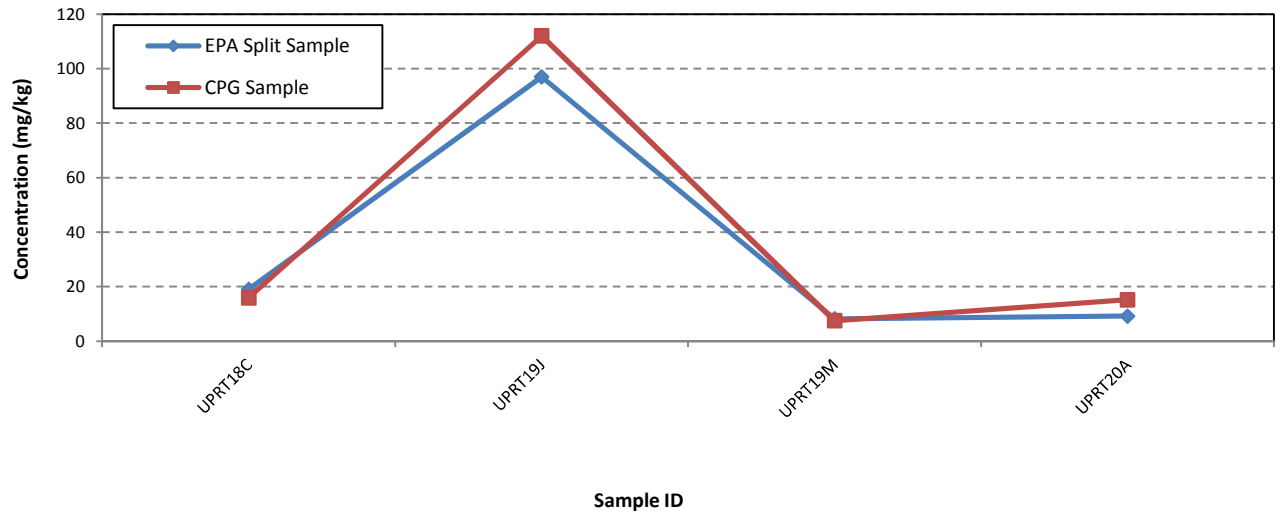



**Figure 41b: Bivariate Plot of Chromium Concentrations**

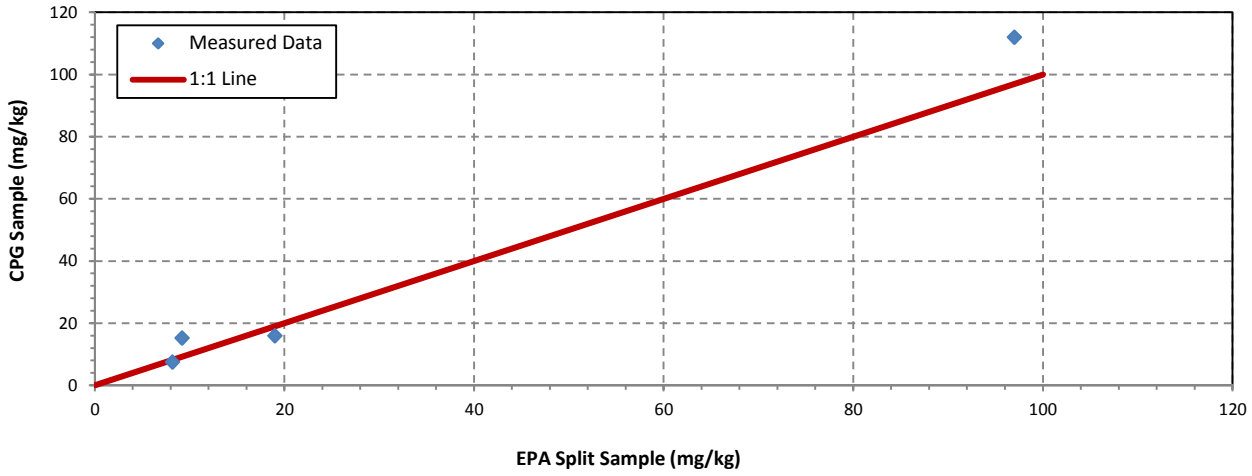
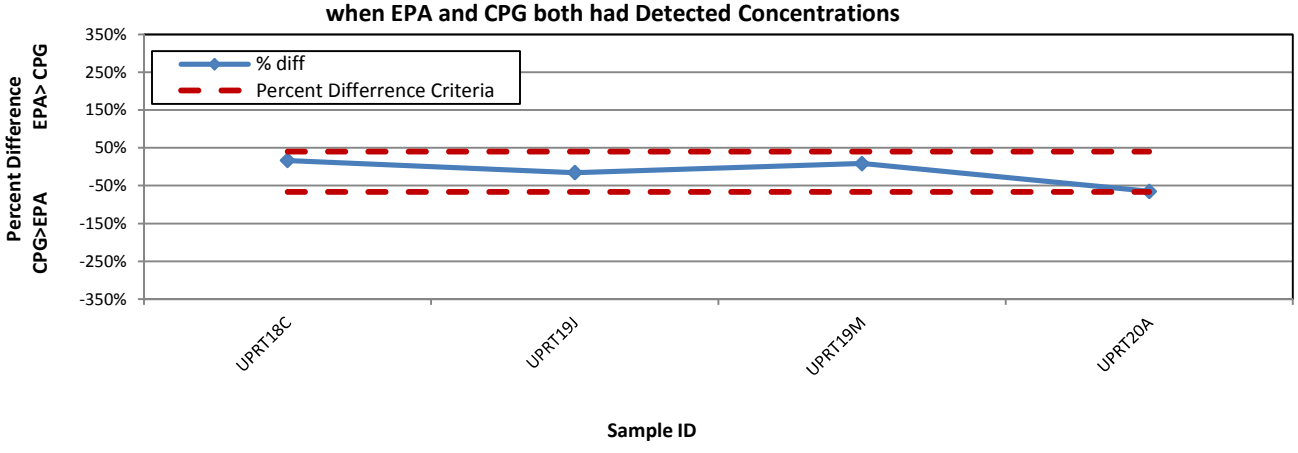



**Figure 41c: Line Plot of Chromium Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment Chromium Concentrations** | **Figure 41** |

CDM Smith

**Figure 42a: Line Plot of Cobalt Concentrations**

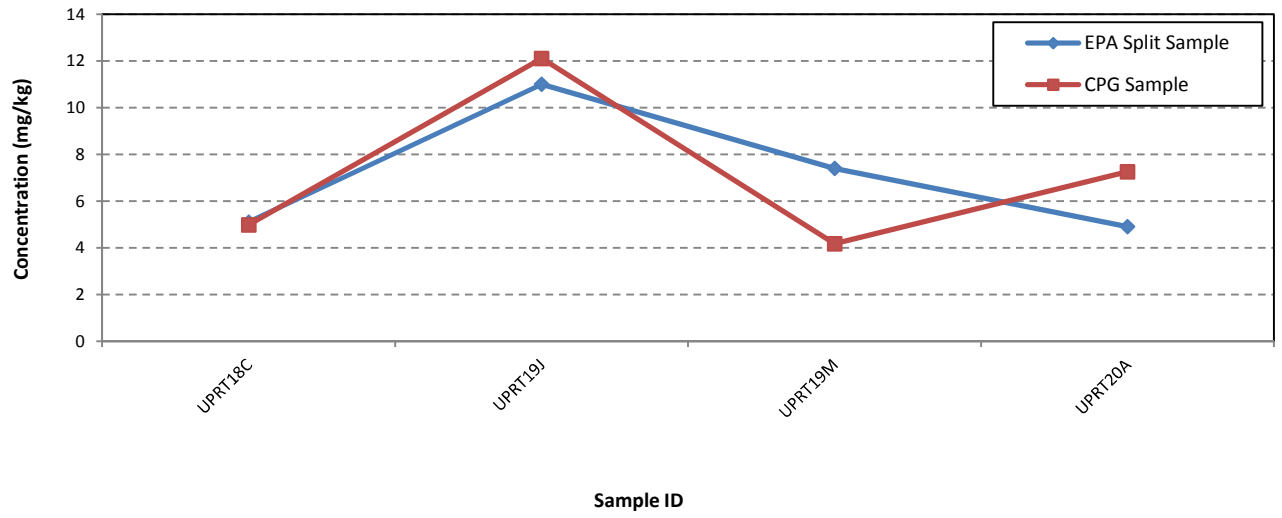



**Figure 42b: Bivariate Plot of Cobalt Concentrations**

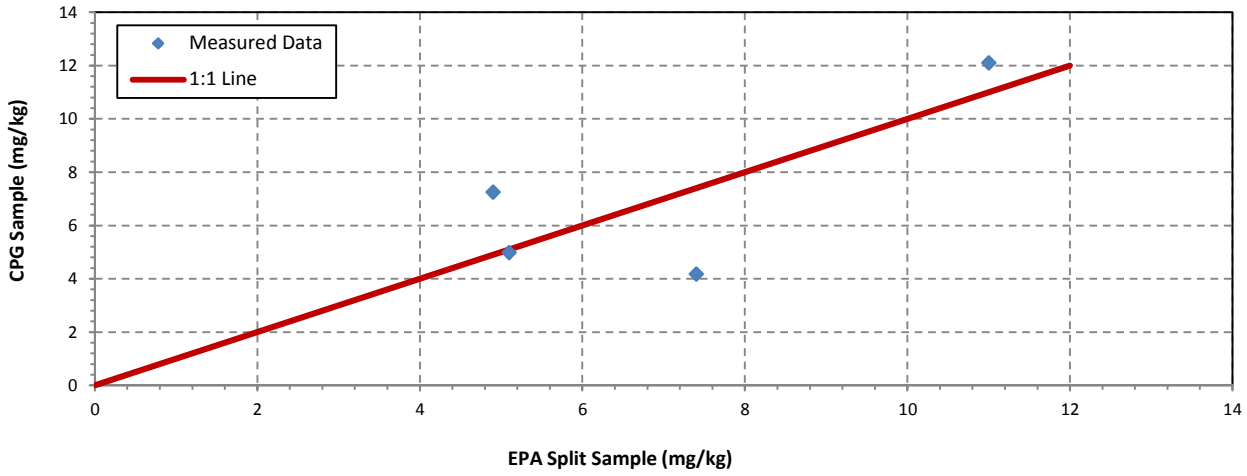
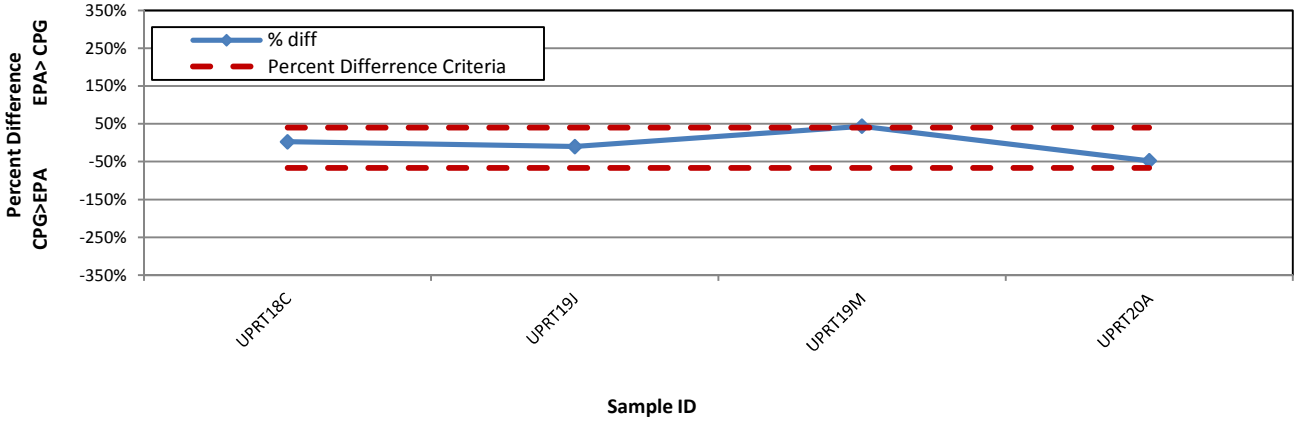



**Figure 42c: Line Plot of Cobalt Percent Differences when EPA and CPG both had Detected Concentrations**




| | | |
|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment Cobalt Concentrations** | **Figure 42** |

CDM Smith

**Figure 43a: Line Plot of Copper Concentrations**

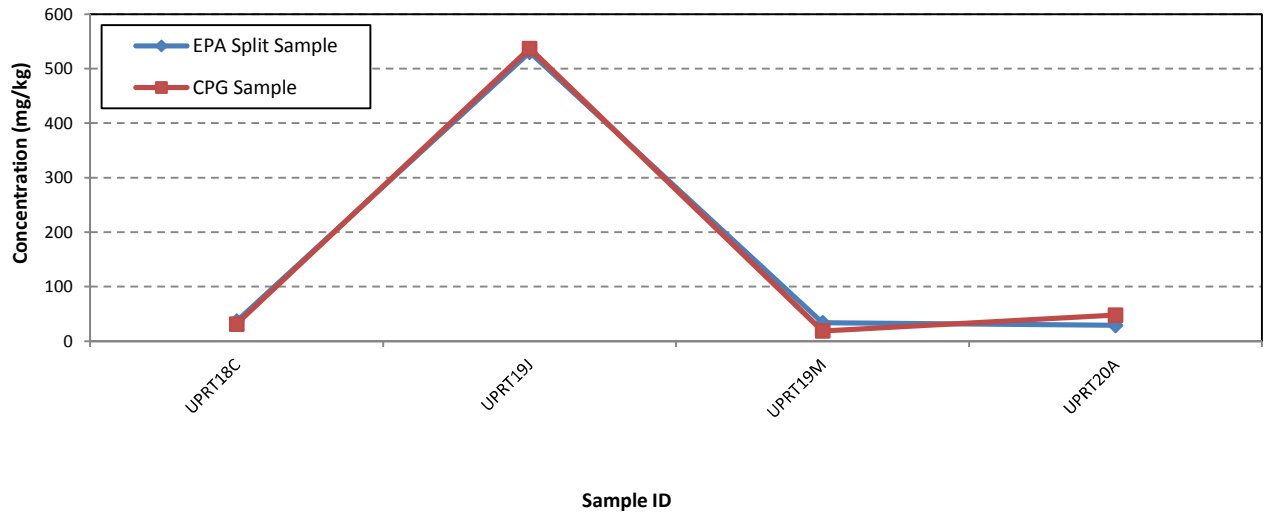



**Figure 43b: Bivariate Plot of Copper Concentrations**

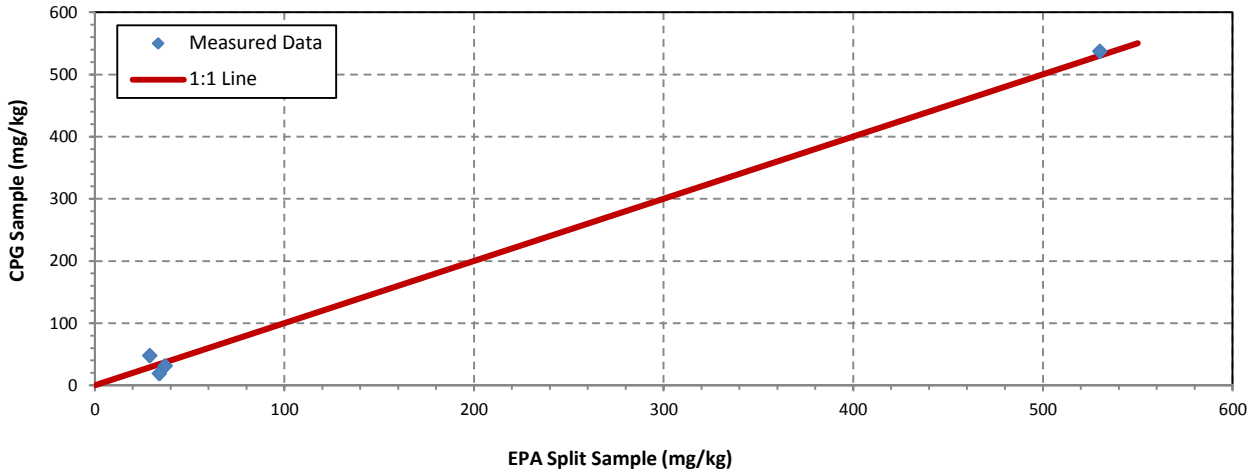
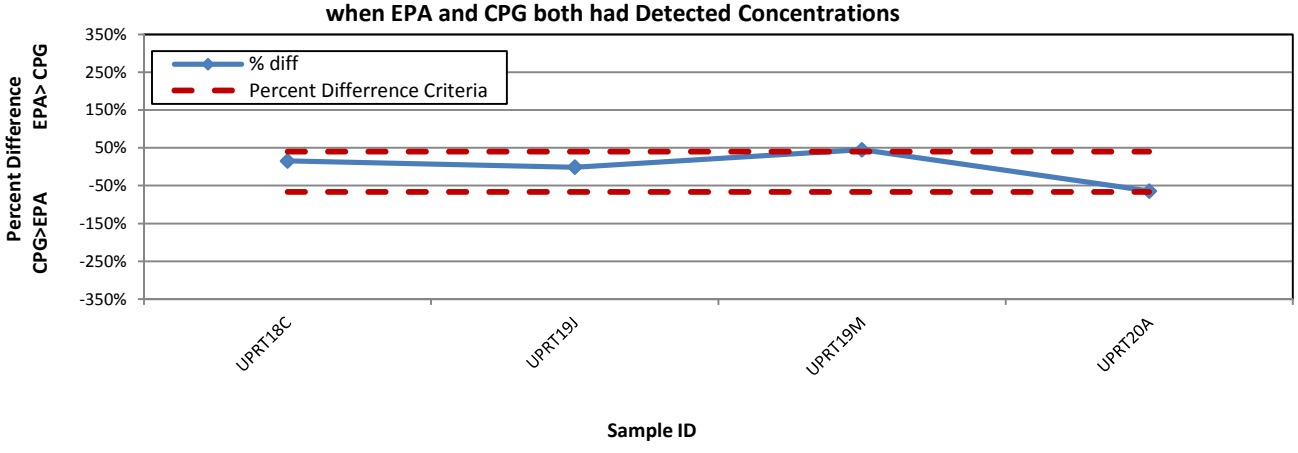
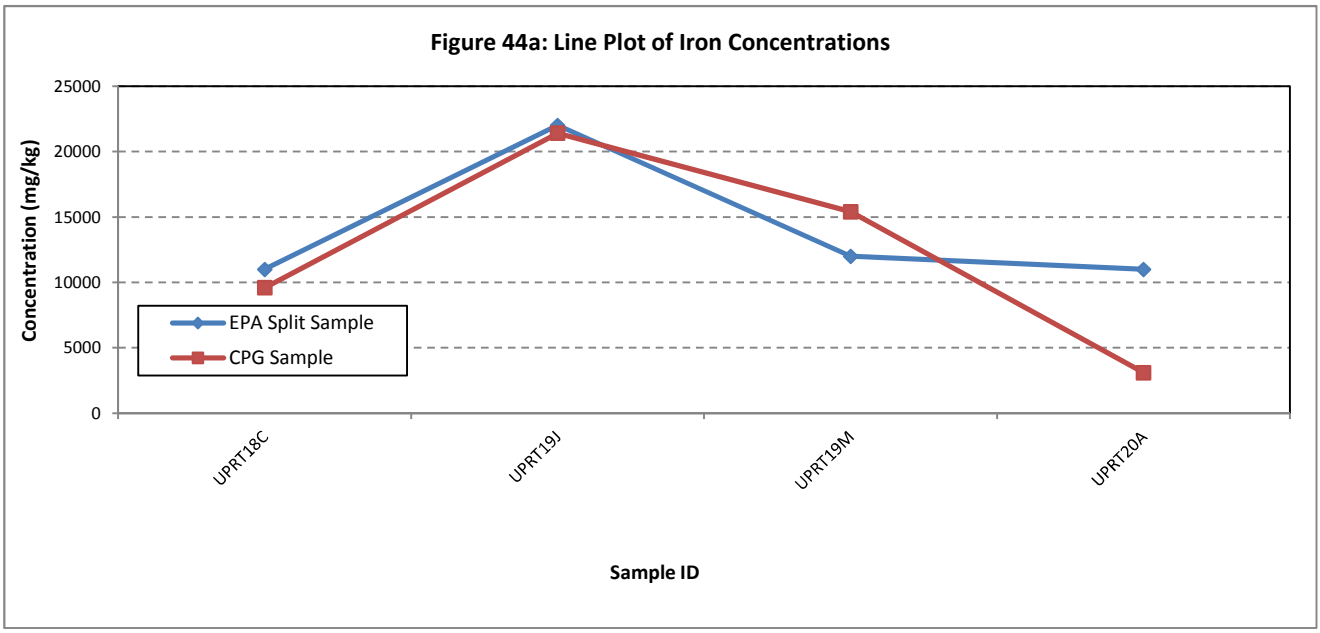


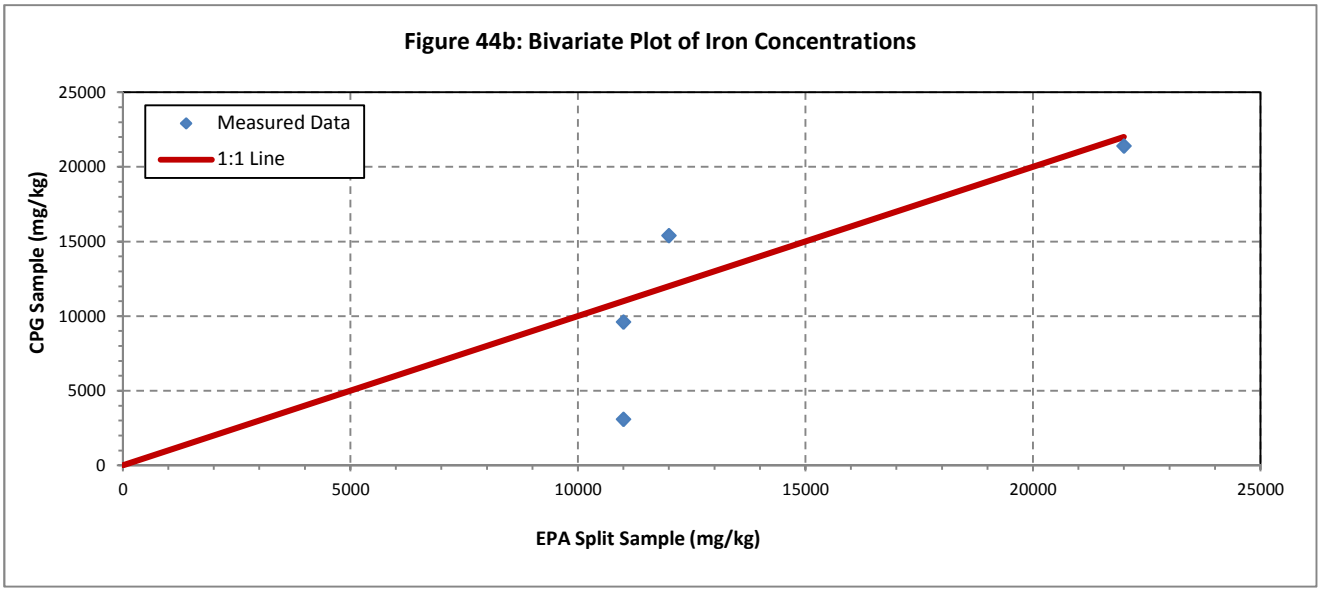

**Figure 43c: Line Plot of Copper Percent Differences when EPA and CPG both had Detected Concentrations**

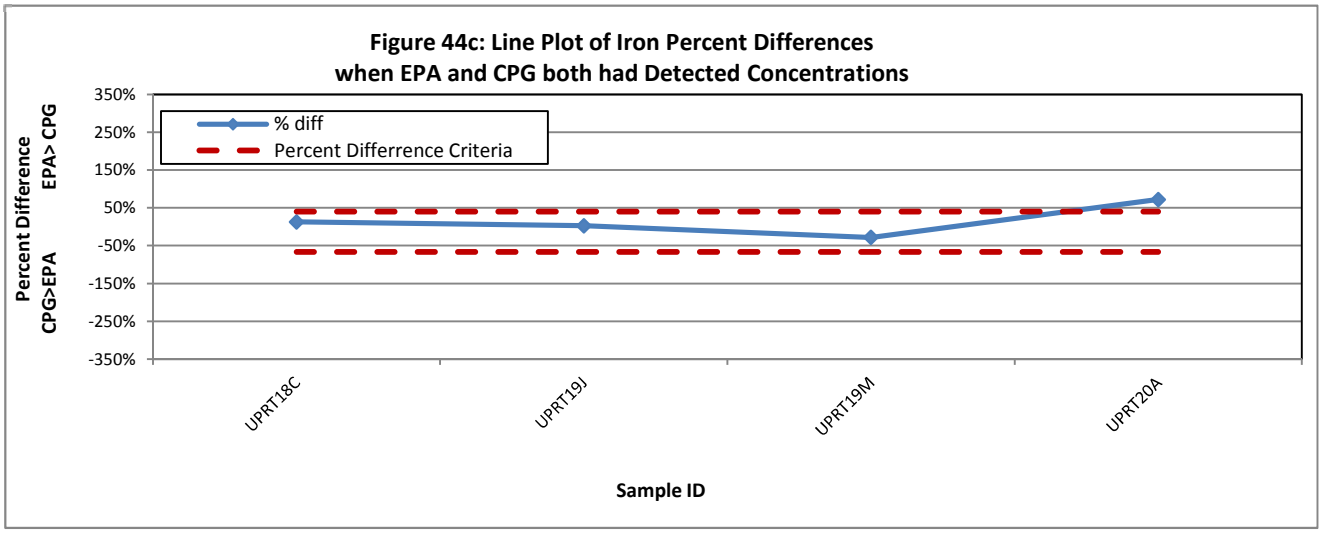



| | | |
|---|---|---|
| US Army Corps of Engineers | **Statistical Plot of Sediment Copper Concentrations** | **Figure 43** |

CDM Smith




US Army Corps of Engineers

**Statistical Plot of Sediment Iron Concentrations**

**Figure 44**

CDM Smith

**Figure 45a: Line Plot of Lead Concentrations**

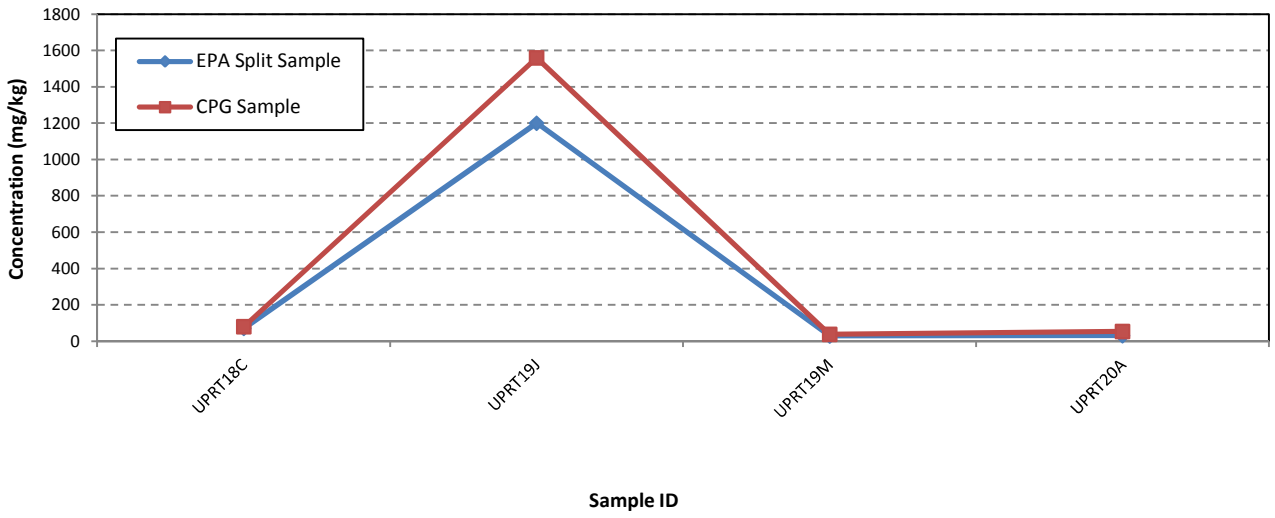



**Figure 45b: Bivariate Plot of Lead Concentrations**

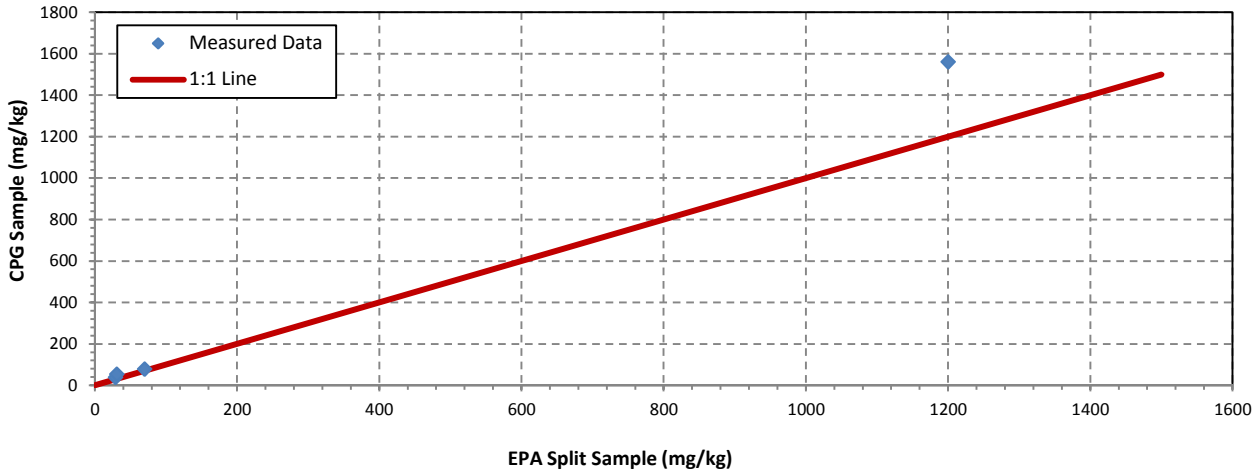
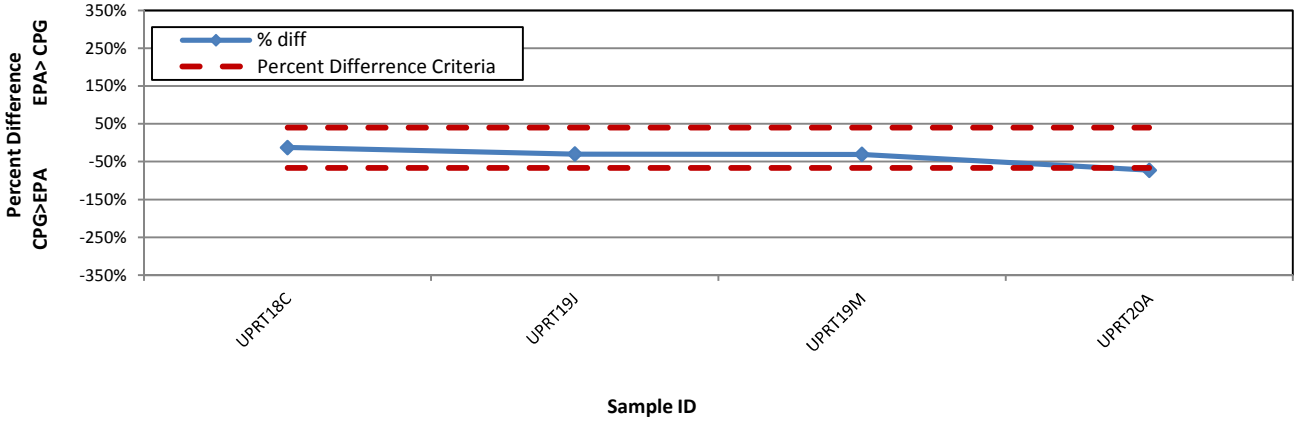



**Figure 45c: Line Plot of Lead Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Lead Concentrations**

**Figure 45**

CDM Smith

**Figure 46a: Line Plot of Nickel Concentrations**

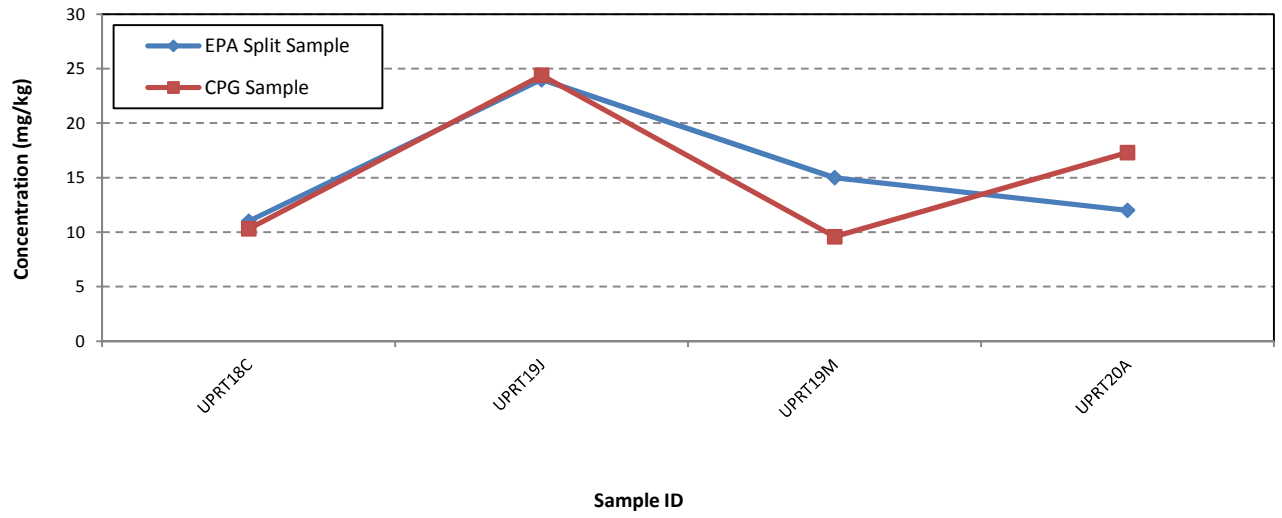



**Figure 46b: Bivariate Plot of Nickel Concentrations**

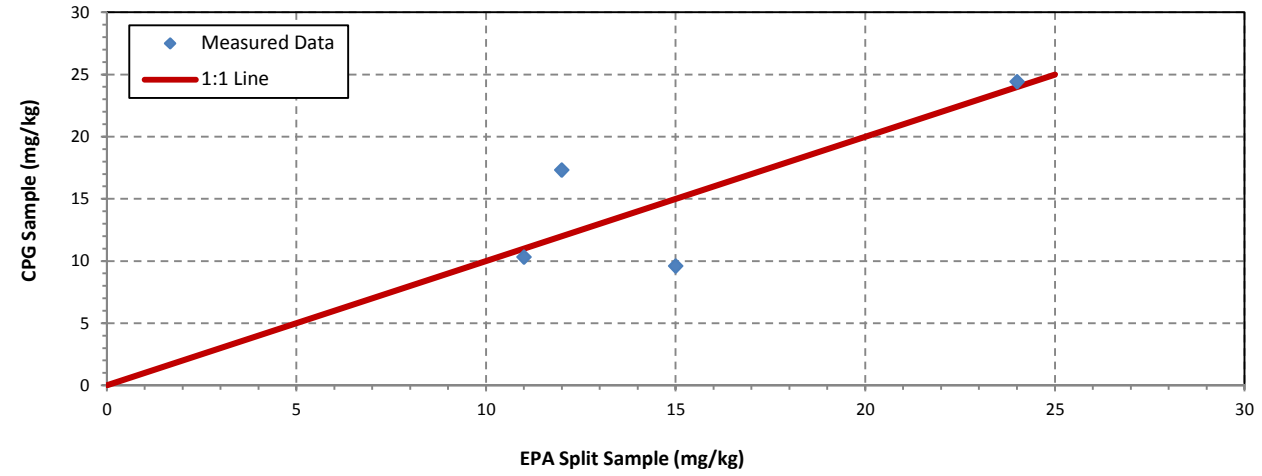
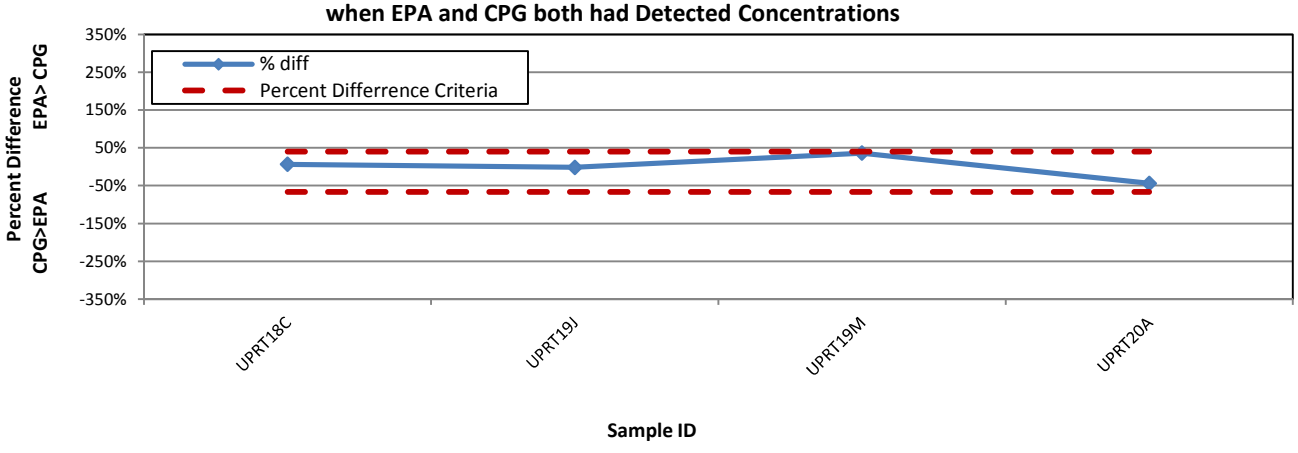



**Figure 46c: Line Plot of Nickel Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Nickel Concentrations**

**Figure 46**

CDM Smith

**Figure 47a: Line Plot of Zinc Concentrations**

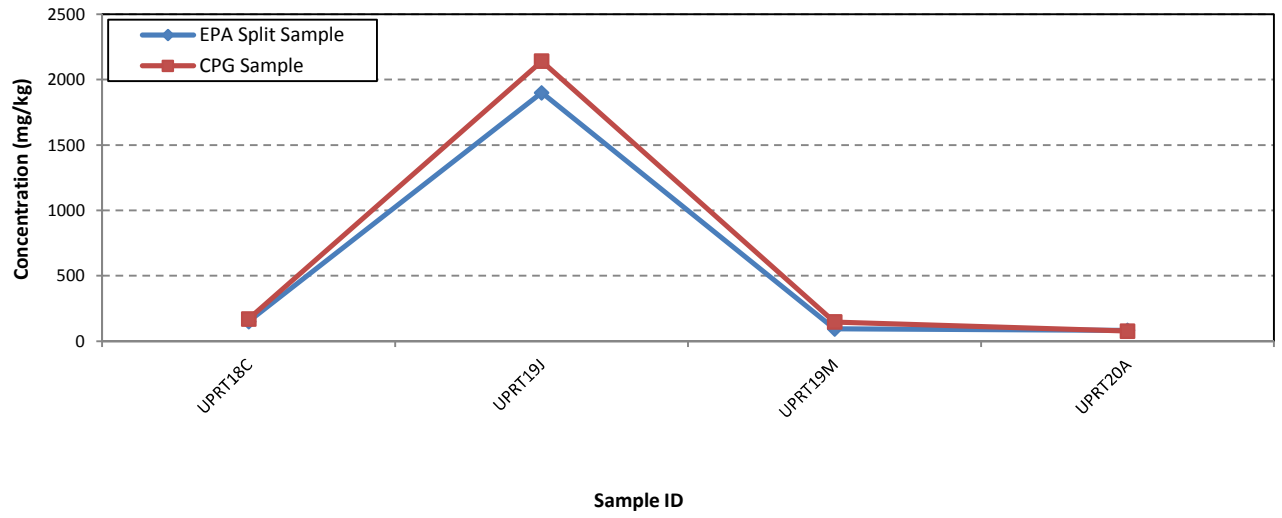



**Figure 47b: Bivariate Plot of Zinc Concentrations**

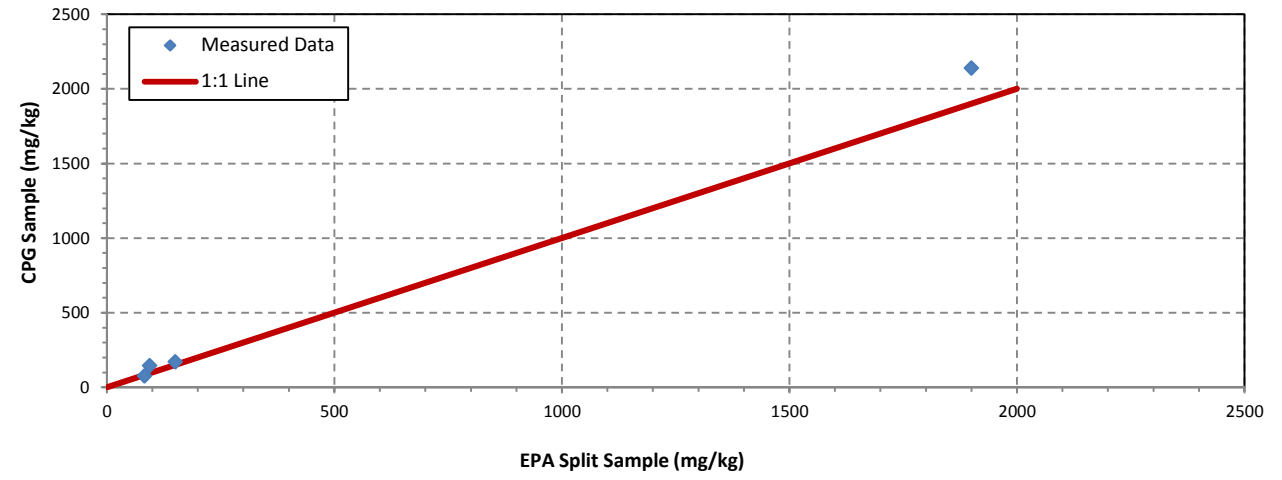
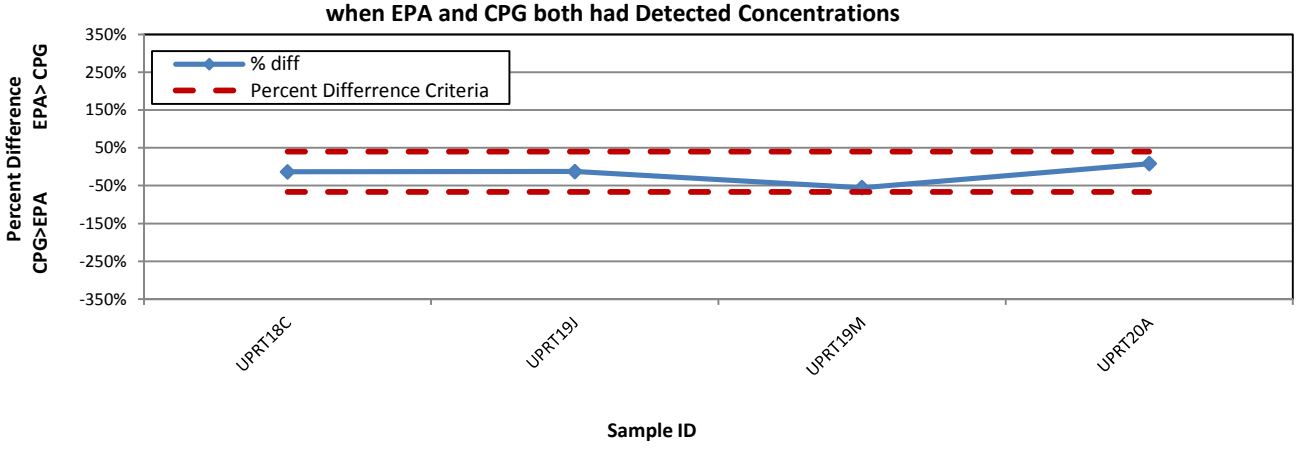



**Figure 47c: Line Plot of Zinc Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Zinc Concentrations**

**Figure 47**

CDM Smith

**Figure 48a: Line Plot of Mercury Concentrations**

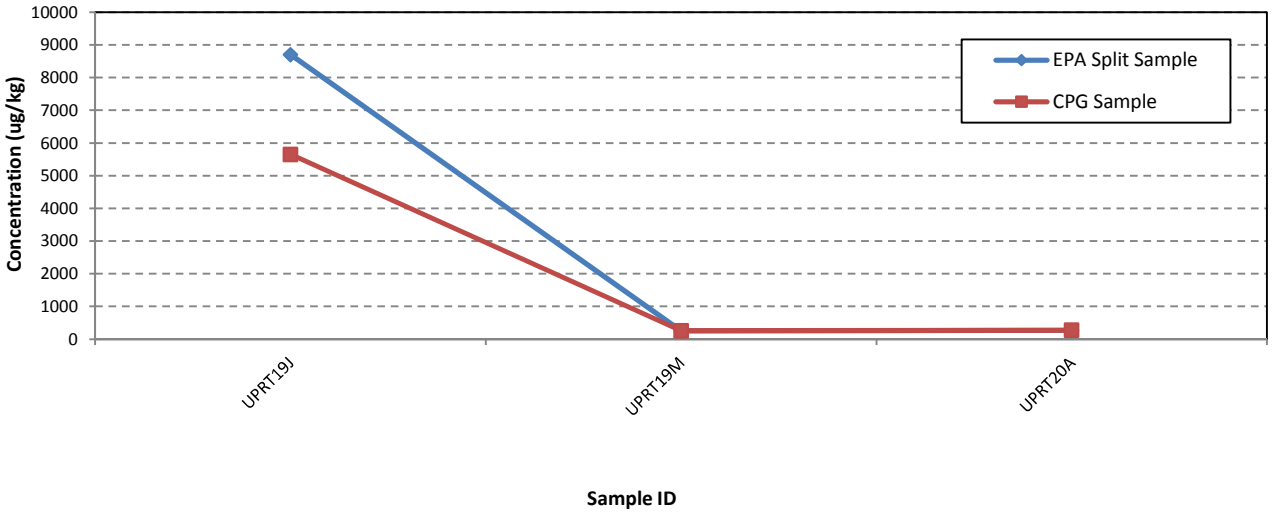



**Figure 48b: Bivariate Plot of Mercury Concentrations**

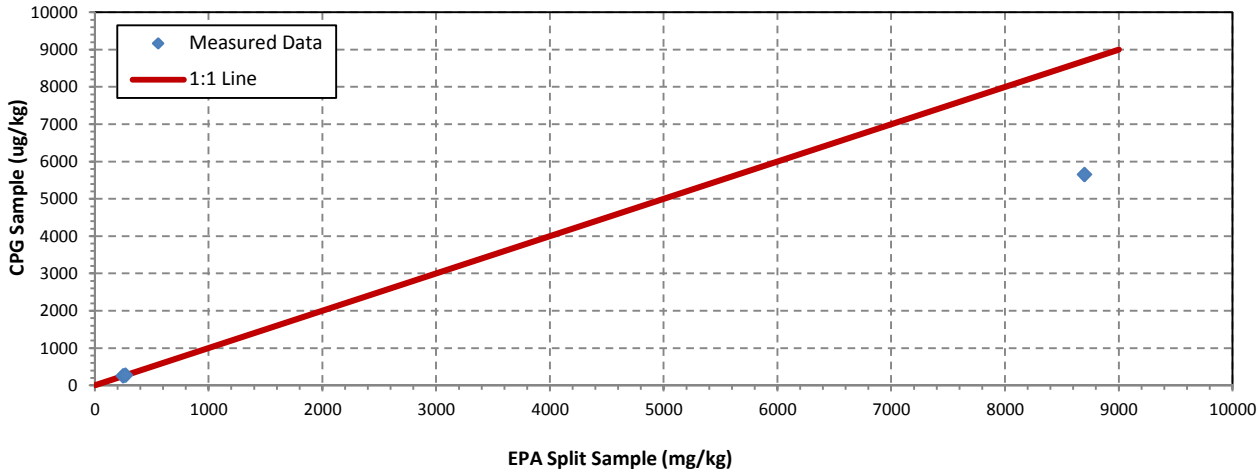
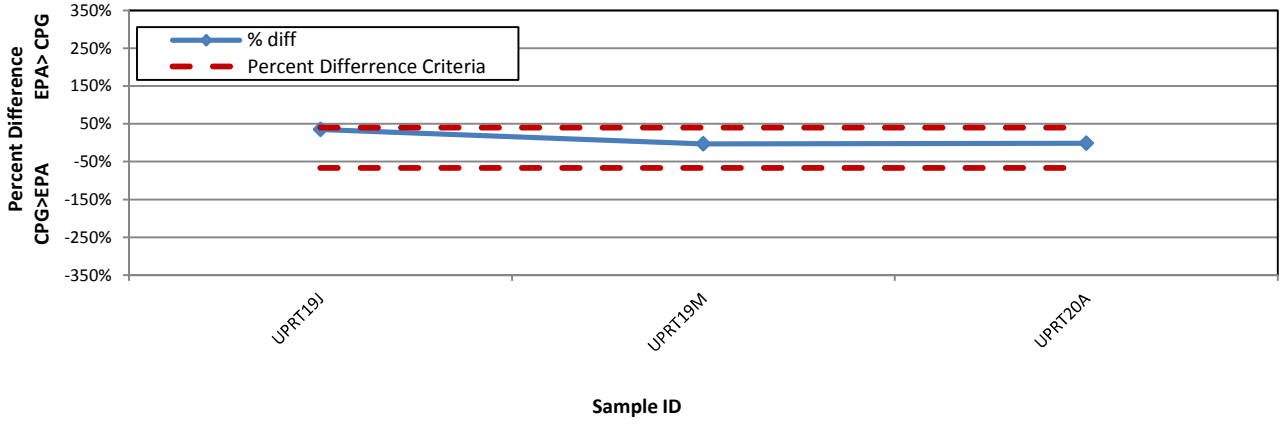



**Figure 48c: Line Plot of Mercury Percent Differences when EPA and CPG both had Detected Concentrations**




US Army Corps of Engineers

**Statistical Plot of Sediment Mercury Concentrations**

**Figure 48**

CDM Smith

**Figure 49a: Line Plot of Dioxins/Furans Scaled Concentrations**

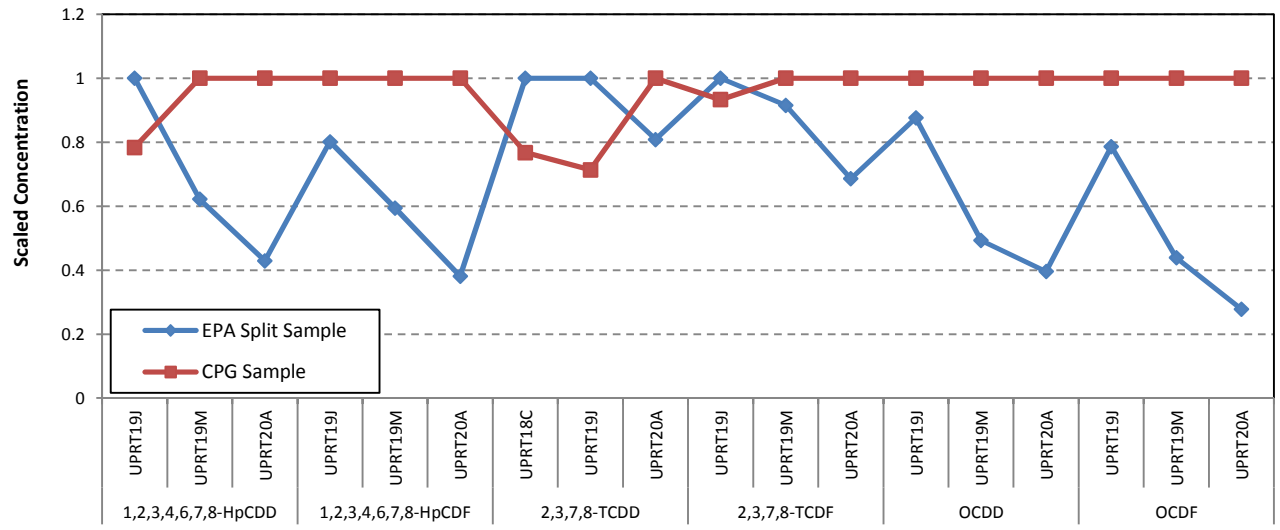



**Figure 49b: Bivariate Plot of Dioxins/Furans Scaled Concentrations**

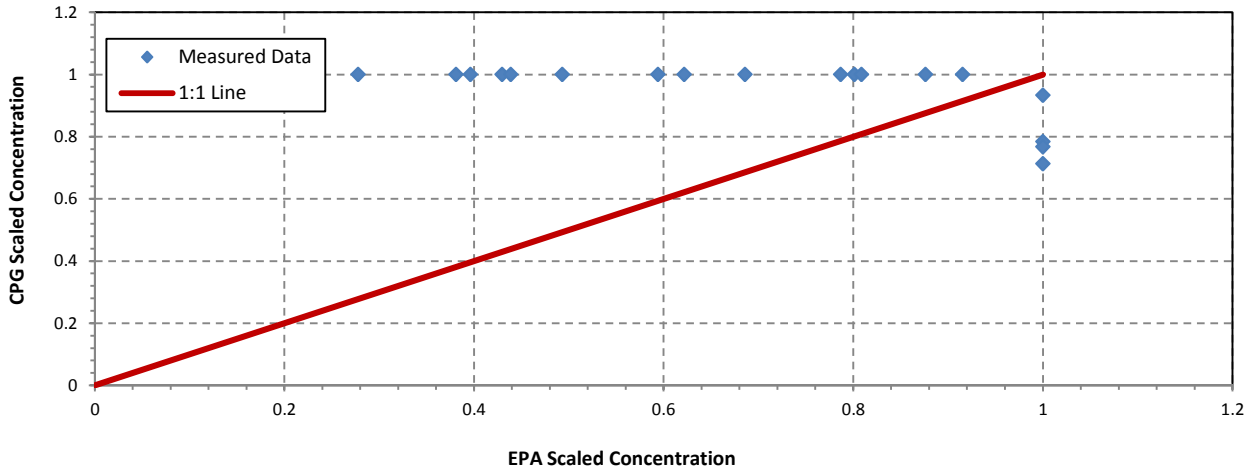
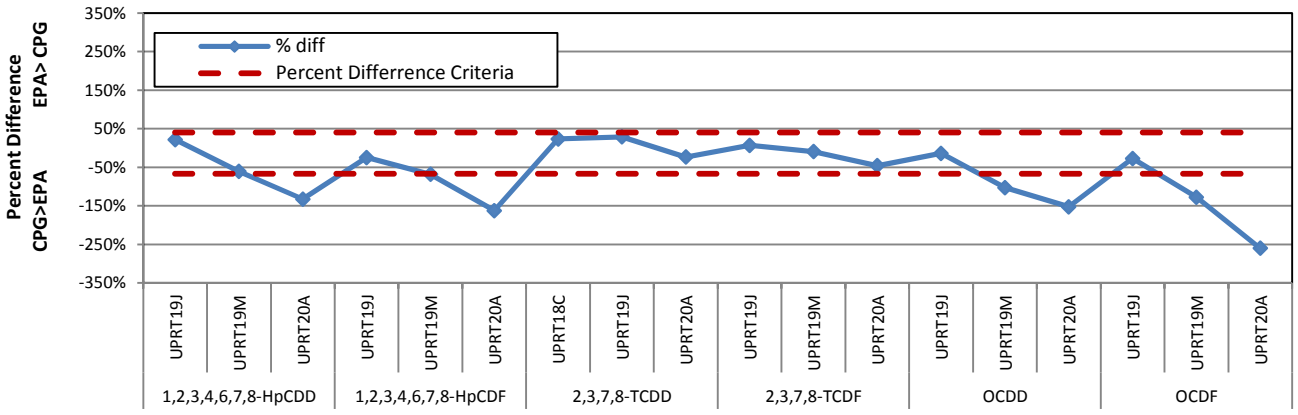



**Figure 49c: Line Plot of Dioxins/Furans Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Dioxins/Furans Scaled Concentrations**

**Figure 49**

HpCDD = heptachlorodibenzo-p-dioxin
HpCDF = heptachlorodibenzofuran
TCDD = tetrachlorodibenzo-p-dioxin
TCDF = tetrachlorodibenzofuran
OCDD = octachlorodibenzo-p-dioxin
OCDF = octachlorodibenzofuran

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**Figure 50a: Line Plot of Pesticides Scaled Concentrations**

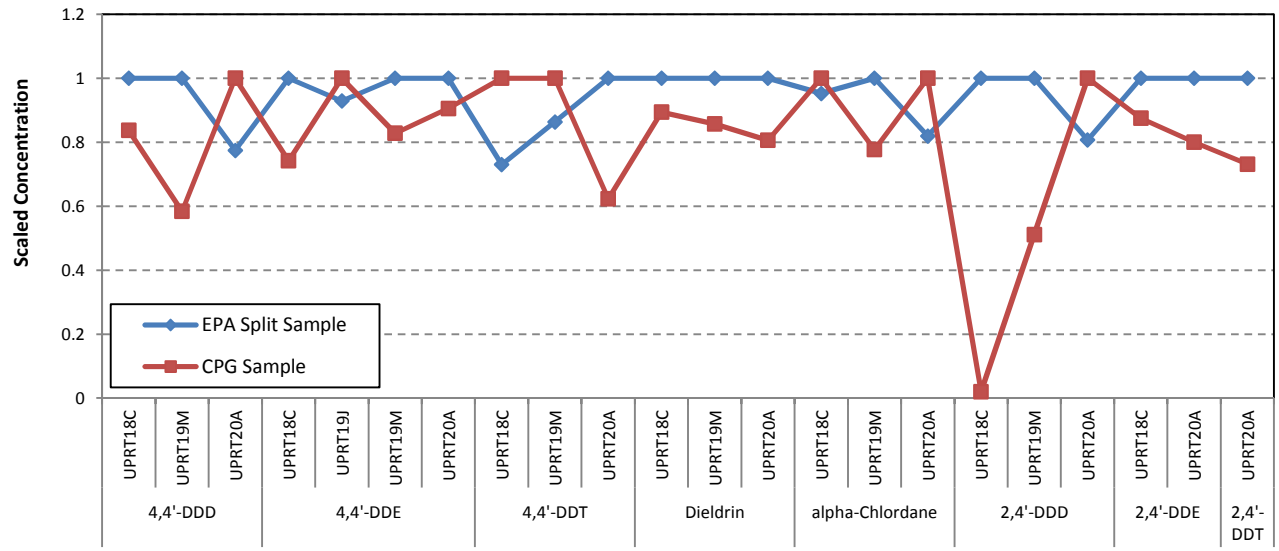



**Figure 50b: Bivariate Plot of Pesticides Scaled Concentrations**

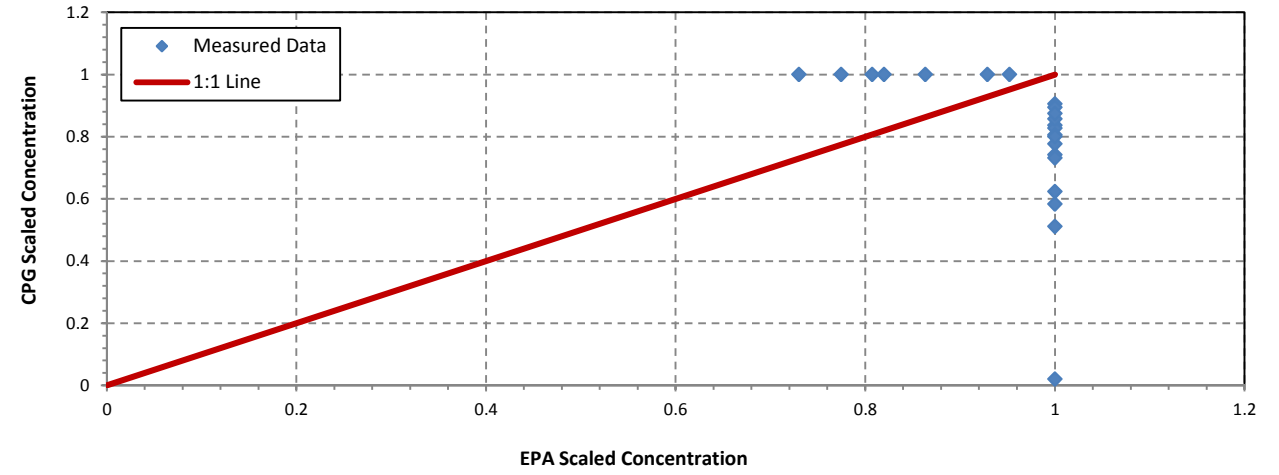
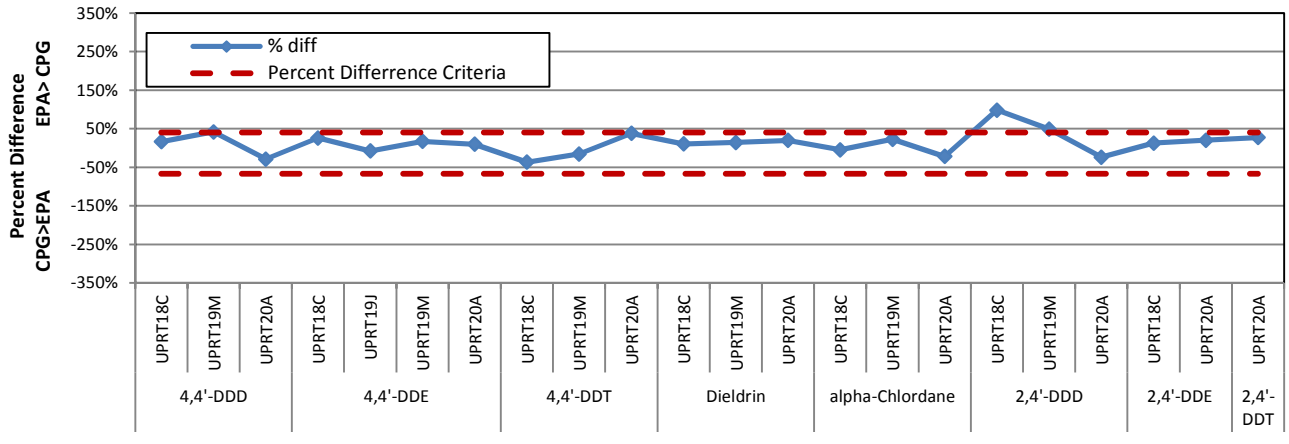



**Figure 50c: Line Plot of Pesticides Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Pesticides Scaled Concentrations**

**Figure 50**

DDD = dichlorodiphenyldichloroethane

DDE = dichlorodiphenyldichloroethylene

DDT = dichlorodiphenyltrichloroethane

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**Figure 51a: Line Plot of Polychlorinated Biphenyls (PCBs) Scaled Concentrations**

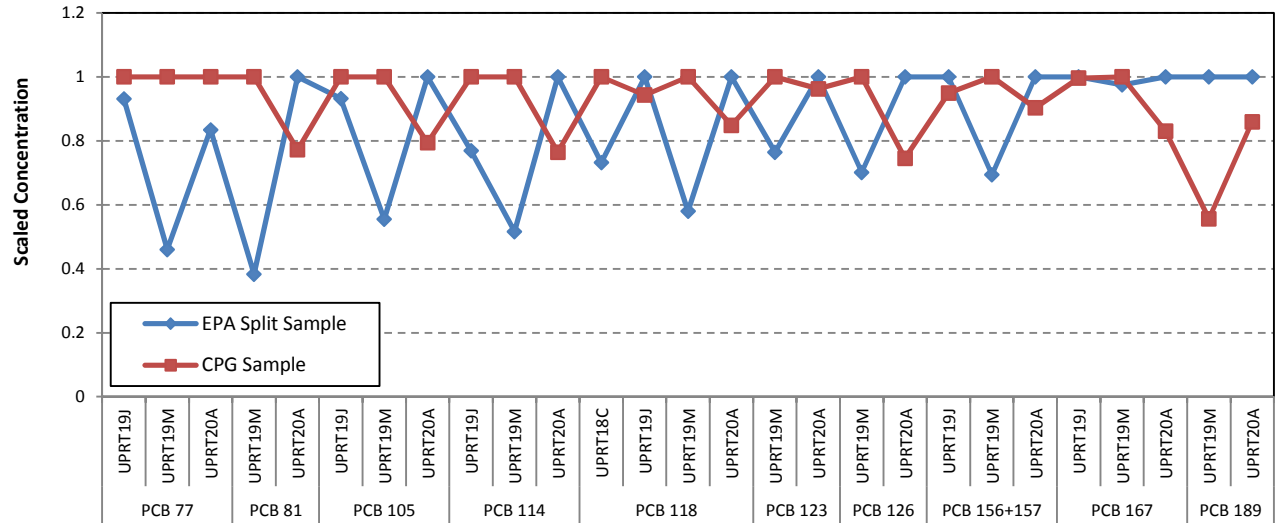



**Figure 51b: Bivariate Plot of Polychlorinated Biphenyls (PCBs) Scaled Concentrations**

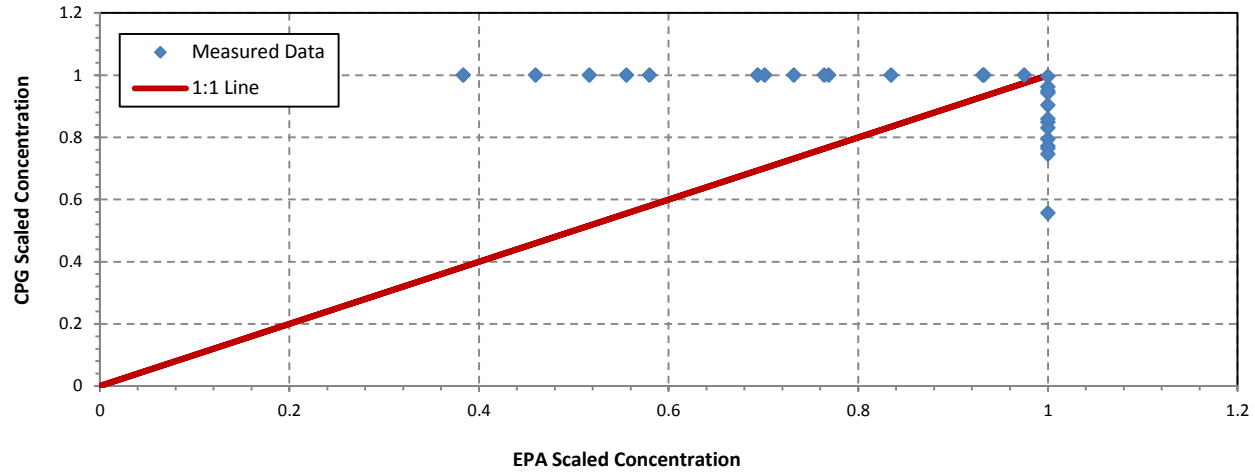
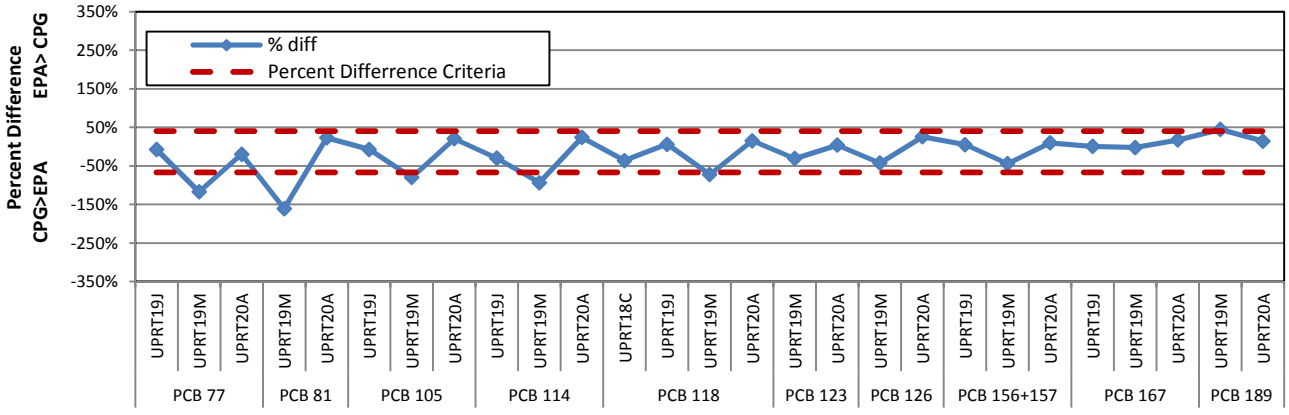



**Figure 51c: Line Plot of Polychlorinated Biphenyls (PCBs) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Polychlorinated Biphenyls (PCBs) Scaled Concentrations**

**Figure 51**

PCB = polychlorinated biphenyl

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**Figure 52a: Line Plot of Polycyclic Aromatic Hydrocarbons (PAHs) Scaled Concentrations**

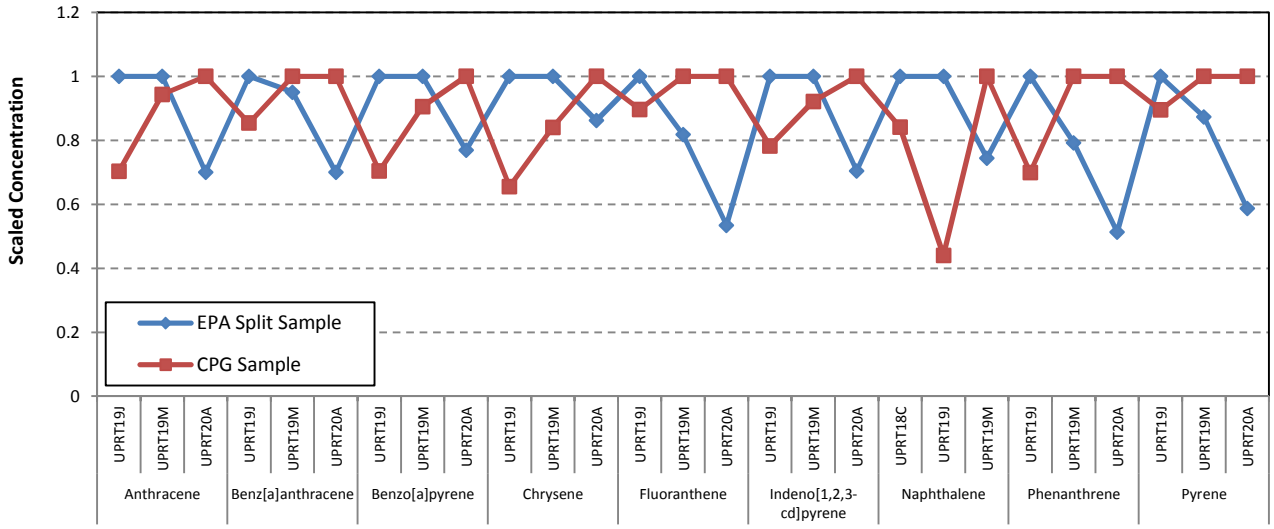



**Figure 52b: Bivariate Plot of Polycyclic Aromatic Hydrocarbons (PAHs) Scaled Concentrations**

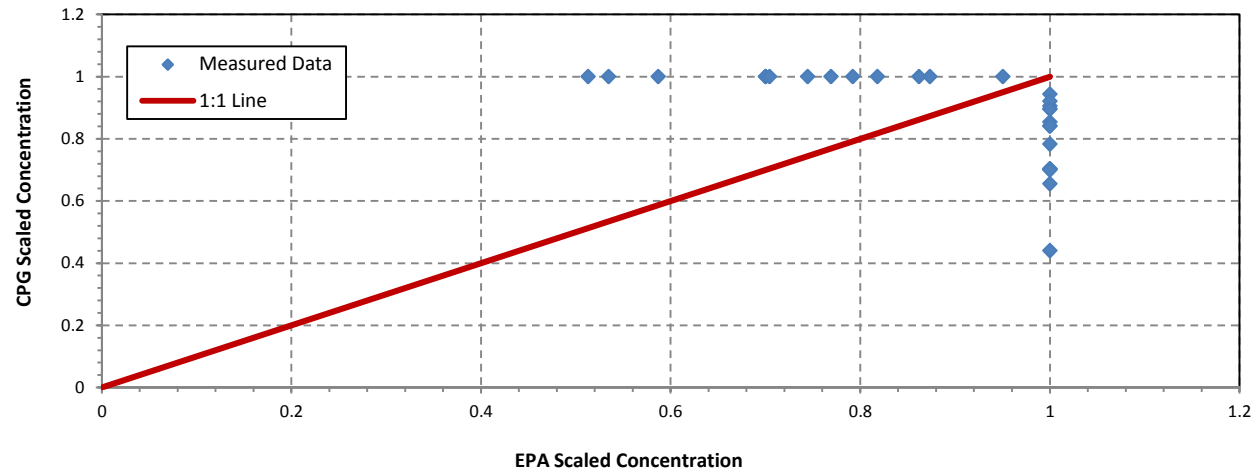
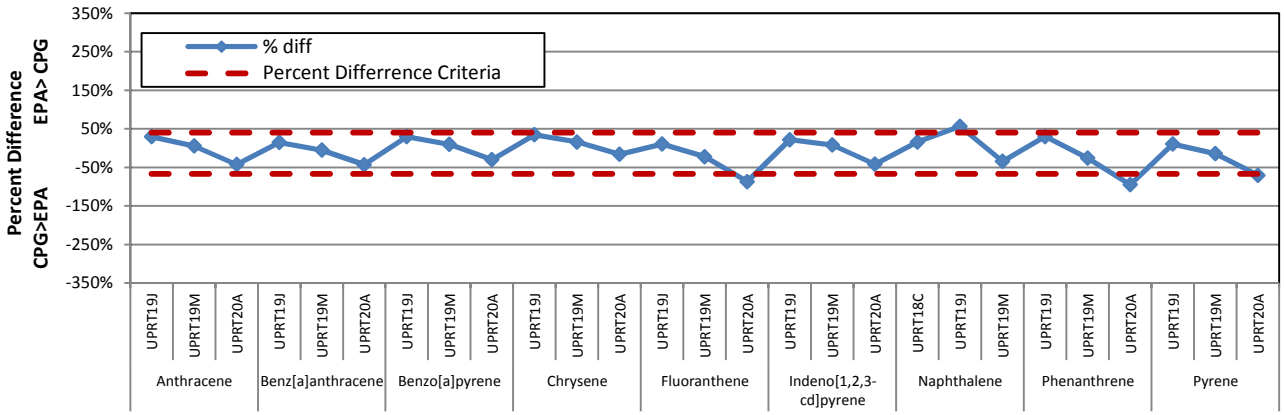



**Figure 52c: Line Plot of Polycyclic Aromatic Hydrocarbons (PAHs) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Polycyclic Aromatic Hydrocarbons (PAHs) Scaled Concentrations**

**Figure 52**

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**Figure 53a: Line Plot of Metals (excluding mercury) Scaled Concentrations**

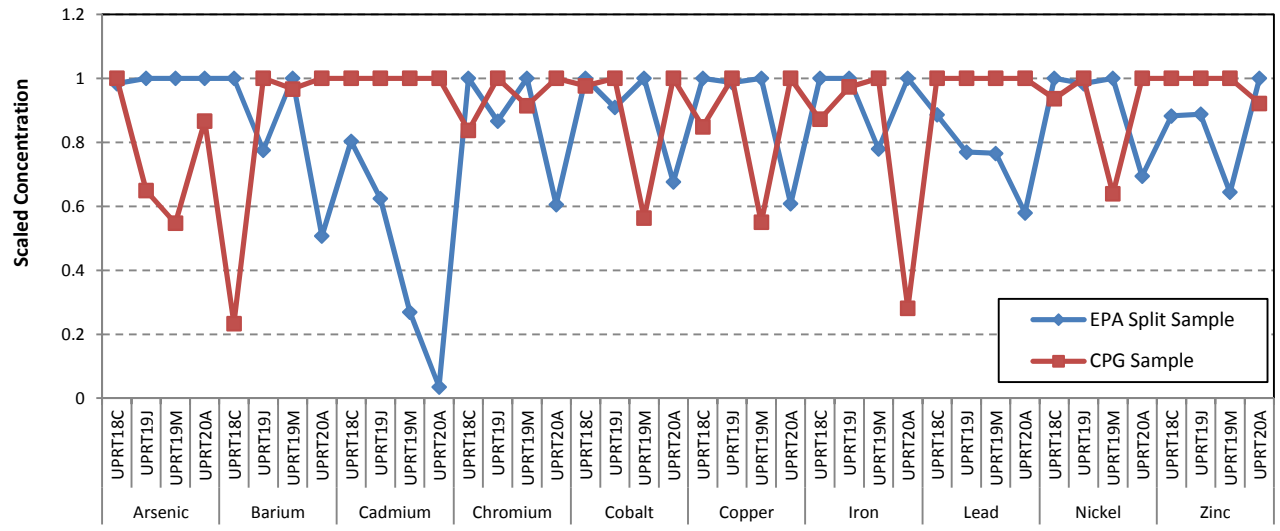



**Figure 53b: Bivariate Plot of Metals (excluding mercury) Scaled Concentrations**

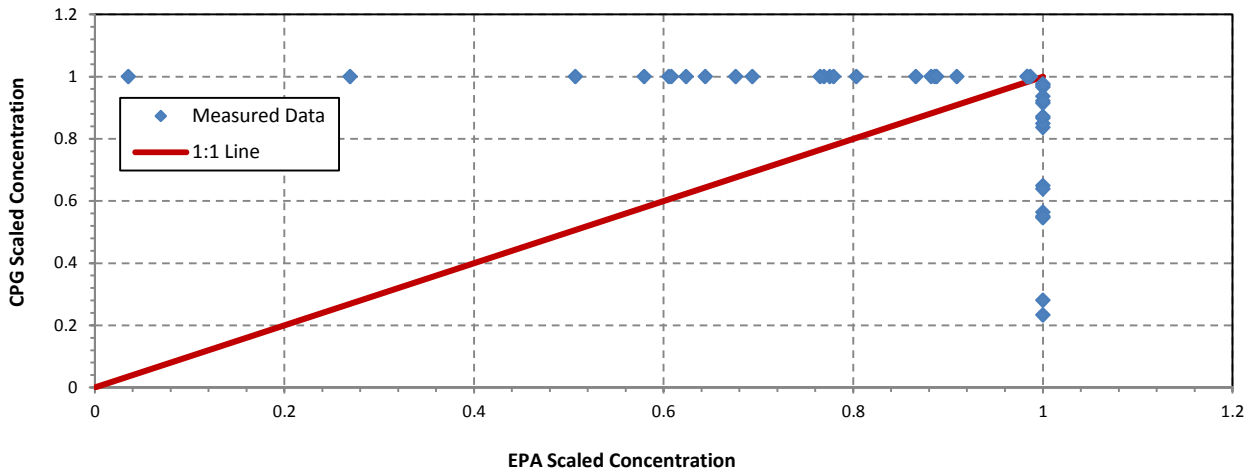
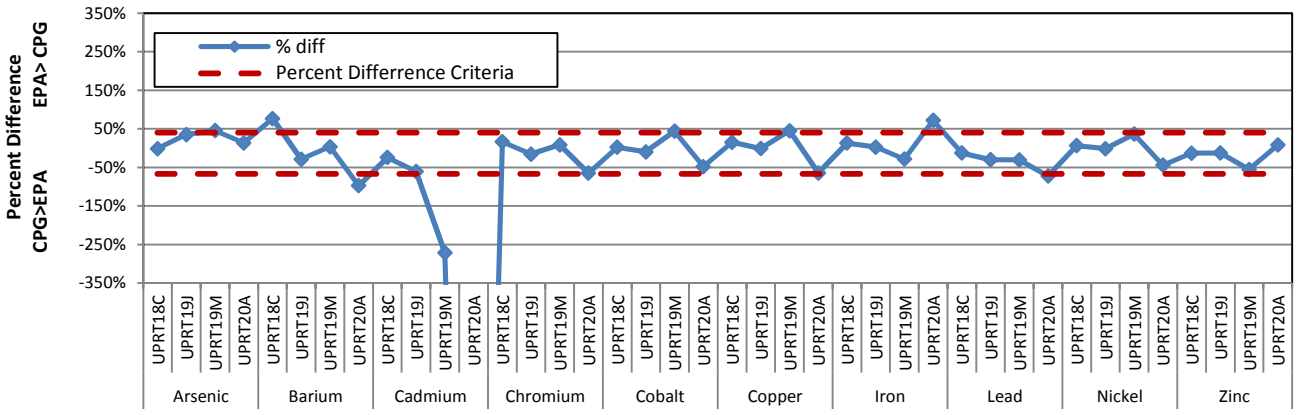



**Figure 53c: Line Plot of Metals (excluding mercury) Percent Differences when EPA and CPG both had Detected Concentrations**

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**Statistical Plot of Sediment Metals (excluding mercury) Scaled Concentrations**

**Figure 53**

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